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THE ROLE OF TECHNOLOGY IN THE EDUCATION, TRAINING AND
RETRAINING OF ADULT WORKERS

A Report prepared for
The Congressional Office of Technology Assessment (OTA)

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TECHNOLOGY AND TRAINING

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TECHNOLOGY AND TRAINING

EXECUTIVE SUMMARY

A central question today in education and training is whether and how new technological tools and devices, such as computers and video disks, can help improve the quality and reduce the costs of instruction. Because of its concern with the problems facing displaced adult workers and employed workers needing to prepare for second and third careers, the Office of Technology Assessment (OTA) called for a study to determine "whether traditional academic teaching (with lectures by a teacher and assignments for the students) and traditional vocational education (with practice on equipment similar to that found in the workplace) are the best or only ways to educate adults?" This report presents the answers that were found during the study.

The report shows how new technological tools or devices are being used in adult education and training; it examines the evidence of their effectiveness and costs; and it suggests prospects for the future use of technologies. Particular attention has been given to uses with displaced and employed workers needing basic skills, high school diplomas and skill upgrading.

THE TECHNOLOGIES.

The technologies examined are: broadcast television, broadcast, cable, Instructional Television Fixed Service (ITFS), video tape, video disk, computers (including computer assisted instruction (CAI), computer managed instruction (CMI), and embedded training,) simulators, emulators, telecommunications, job aids, and "off-the-shelf" programs.

Television — Of all of these technologies, television has been around the longest. There is no doubt of its broad impact on the American culture and its role in informing people and shaping their values. In direct instruction of adults it has had more limited success. The greatest virtue of television as an instructional medium is its ability to deliver instruction at a distance to individuals who for reasons of location, scheduling, physical capacity or inclination cannot attend regular classes.

Studies have indicated that students generally learn as well via television as through direct instruction. The development and delivery of televised instruction can be very expensive, particularly if an effort is made to emulate the production values of commercial television. When there are large enough numbers of students interested in a particular televised course, the cost per student can be very competitive with

classroom instruction. However, since such conditions are not very common, television has not achieved the use that its early advocates had anticipated.

Video tape and disk — Another disadvantage of television is that it is a passive medium with little opportunity for activity by the student or interaction with the instructor. Video tape and, even more, video disk give students a more active role because they can use the programs at times and ways under their own control, rather than being restricted by a broadcast schedule or preset sequencing and pacing of the instruction. When coupled with a computer they can provide a high degree of interactivity. In spite of the considerable promise from this combination, instructional use is still quite limited, in part because of the costs of equipment and course development, in part because not enough experimentation has yet been done on how to produce effective instruction with these complex media.

Computers — Of all of the devices, computers have excited the most interest for instructional applications. With their vast capacity for handling information, the almost infinite variety of ways that they can be programmed to respond to user commands, and their rapidly declining cost and increasing power, they seem to many to be the ideal "teaching machine." Taking advantage of these characteristics, thousands of teachers and courseware authors have produced computer assisted instruction (CAI) in almost every subject matter field. There have also been a few very large scale development efforts such as that which has produced the PLATO system.

In spite of the great promise, the controlled studies that have been done to date, of which ones involving adults are very few, have shown that CAI produces only small gains in achievement. Its most significant contributions are in the reduction in the amount of time needed for instruction and in holding quality constant when large numbers are to be taught the same material in differing locations. It is these features that have made CAI attractive to business and the military, since the time of students while in training is one of the largest components of the cost of training.

Another application is computer managed instruction (CMI). Management aids are particularly critical in any large scale effort to tailor instruction to meet the varying needs and abilities of individual students. When instruction is "individualized," it becomes a monumental task to track each student's progress through the differing possible paths in an instructional sequence and insure that the right lesson and material is assigned and available at the right time. CMI systems have been designed to assist with these tasks.

While CMI does help with the management tasks, there is no strong evidence that students in CMI programs perform better than students in more traditional arrangements. Because of the numbers of factors involved in assessing costs of such systems, it is also difficult to determine whether or not CMI is cost-effective.

Embedded training — Because microchips are being incorporated into so many devices that are being used by workers to perform their daily tasks (the word processor being only the most visible of many), it is becoming possible to use the power of the chip to "embed" training in the devices themselves. This is in a way a special application of CAI, except that instead of providing instruction in anticipation of need, instruction is provided when needed at the point of application. Indications from the businesses where such embedded training is being employed is that it is highly cost-effective even though the costs of the initial design are high. The economies come because one learns only what is needed to do a particular task, with minimum time taken from the job, and little opportunity to forget or misapply the instruction.

Simulators and emulators -- When training on a real device or in an actual situation would be too dangerous or costly to provide for adequate instruction, simulators or emulators are used. Many of these now also use microchips. While flight-training simulators have conclusively proved their worth, there is still much debate about other simulators because of the mixed results obtained in the few systematic studies that there have been of their use.

Computer graphics — One of the applications of computers that is coming into increasing prominence in instruction is computer graphics. Ours is a highly visually oriented society, thanks very much to television. With the cost of graphics devices rapidly coming down and their capacities going up, it is becoming possible to produce highly interactive, visually powerful, instructional materials that are beginning to be used in many areas from basic skills instruction to the advanced training of such diverse specialists as physicians, engineers and textile designers.

Telecommunications — Another of the technological developments that is finding a significant place in adult education and training is the increasing capacity to provide two-way communications, a capability missing from "traditional" television. Now with the increasing availability of audio, video and computer conferencing, this limitation is being removed. Each of these types of conferencing has its strengths and weaknesses for instructional use and these are now being explored in a number of efforts throughout the country.

Job aids -- One of the clear findings from this study is that complex and costly technologies are not always better when it comes to instructional applications. One of the indications of this is the development of job aids, which are often chosen as alternatives to training. Embedded training, described above, is one form that job aids can take. Other aids, provided in various formats, are designed to reduce the reliance on recalled skills and knowledge. Often used in conjunction with prior training, job aids are claimed to be cost-effective ways to insure effective performance on jobs in which specific skills are only infrequently called for.

Off-the-shelf-programs -- The training literature is filled with advertisements for programs using various media to solve a myriad of training problems. This study could not begin to examine this mass of material to determine the extent of use or what the evidence is for effectiveness. An effort to provide guidance in decisions on what to use has recently begun among the professionals in the training field.

THE SETTINGS.

The greatest activity in the development and use of technology for adult education and training has taken place in industry and the military. With some notable exceptions, schools, community and four-year colleges and universities have been slower to adopt new approaches. Perhaps the most significant development is the growing collaboration between industries and specific schools, colleges or universities to promote the transfer of the training function from the companies in which special systems have been devised to institutions that can provide for on-going training. "Partnerships" and "collaboration" are the watchwords for the developing relationships in the provision of training, particularly in areas of high technology.

THE STUDIES.

In spite of the long interest of the military in training technology, and the growing concern with effective training in business and industry, one of the major findings of the study was that there have been few systematic studies involving adult students comparing educational technologies with traditional instruction. The most extensive studies have been done by the military services and yet even these do not provide a solid basis for making decisions regarding the use of technologies. Part of the reason for the lack of studies has been the limited resources available for research in adult education and training; part has been the difficulty of finding situations in which the large numbers of variables that should be examined can be systematically studied; part has been the relative newness of

most of the technologies; and a significant part has come from the judgement by many in industry that controlled studies are not necessary to determine whether or not a particular training device or program is effective. "It clearly works or it doesn't," is a typical business attitude.

CAI IN ADULT BASIC EDUCATION.

This conclusion about the value of studies applies as well to the applications of CAI for adult basic education, a special interest of this study. Intuitively one might think that the computer would be an ideal device for assisting adults with low academic skills because it is patient, non-judgemental, private and can be offered in an environment totally different from school with all of its associations, in many cases, with prior failure. Yet the limited efforts to apply this and other technologies with adults who need considerable learning help, have as yet not lived up to expectations. In part this is because technology-based instruction usually requires more up-front funding than is available to programs seeking to serve this population; and in part it is due to the need of these people for lots of personal attention from instructors, which reduces the potential cost advantage of the technologies.

THE ROLE OF SOCIAL INTERACTION.

On this last point, one of the findings of the study was the importance of access to live instructors stressed by both trainers and students. The need for social interaction during learning probably explains why adults, when asked, still prefer traditional lectures to any media, although unfamiliarity with media undoubtedly plays a part in this preference.

INSTRUCTIONAL DESIGN.

Another factor frequently cited by interviewees in the study that might account for the difficulty of determining the place and value of technologies in instruction, is the limited attention often paid to the need for systematic analysis prior to the establishment of a training program. If an organization is not clear as to what changes in outcome or performance are to be expected from the introduction of any training program, it has a weak base on which to make decisions about which approaches are most effective. Proper design strategies, many urged, are more important than specific delivery systems or devices.

COSTS.

The most persistent question regarding the application of technology to training is the matter of costs. Although many users of technologies could give cost figures, because of the

lack of standardization in the way that costs and benefits are determined, little confidence can be placed in the available data. Costs for differing technologies vary widely, but there is general agreement that the "up-front" costs of technologies are almost always greater than traditional instruction. Beyond this, it is extremely difficult to generalize about costs and the economic value of the benefits from the differing approaches. Nonetheless, it is generally believed that the larger the numbers of students who will be receiving the same instruction and the longer the time period over which the program will be used, the more likely it is that technology-based approaches will be both cost-effective and insure consistency of training over the life-span of the program. There is not much data as yet to support these beliefs.

BARRIERS TO TECHNOLOGY IN TRAINING.

Because the costs of technology are going down and traditional instruction is going up, cost as a barrier to the adoption of instructional technology is going down. Two other barriers are likely to be somewhat more resistant to rapid change: the attitudes of managers and faculties and the continuing lack of effectiveness of many of the programs. The growing availability of computers may help significantly to reduce both of these barriers in the next few years.

LESSONS FROM HISTORY.

However, the history of efforts to introduce technology into instruction are not encouraging for the future. The histories of programmed and individualized instruction and 8mm film may help both temper extravagant expectations from any particular technology and, at the same time, indicate that considerable progress is being made in understanding the underlying learning and instructional processes that must be mastered before any technology will be effective.

CONCLUSIONS.

Thus the answer to the original question posed by DTA is that there are alternatives to the traditional forms of adult education and vocational training, but it is too soon to say yet which of them are going to prove to be most effective, acceptable to students, instructors and institutions, and economically viable. There are a number of conclusions from the study in which a high degree of confidence can be placed:

1. No single device or technology will be the answer to all training needs. Those needs and the variability of individuals is too great to expect that any one approach will fit all.

2. Some technologies, particularly those employing microprocessors, will make major contributions to the improvement of instruction.

3. Large investments in development and experimentation will have to be made before those benefits are widely realized.

4. The most effective use of devices for instruction will be in situations where the device itself is the object of instruction, as when computers are used to teach the use of computers.

5. Live instructors will continue to play an important role in instruction, particularly in helping those adults with the greatest difficulty in becoming self-directing learners.

6. The development of effective applications of technology to the instruction of adults will benefit from extensive dissemination of successful practices and from policies both at the institutional and governmental levels that recognize the critical importance of the investment of up-front time and money.

7. Systematic studies to demonstrate the value of particular programs, devices and training strategies will help improve decision making regarding training technologies, but there are no strong incentives for organizations doing training to produce such studies, and their absence will not be a significant barrier to the further introduction of technologies in adult training and education.

I. INTRODUCTION.

A central question today in education and training is whether and how new technological tools and devices, such as computers and video disks, can help improve the quality and reduce the costs of instruction. Because of its concern with the problems facing displaced adult workers and employed workers needing to prepare for second and third careers, the Office of Technology Assessment (OTA) called for a study of that question with specific focus on adult workers. It asked "whether traditional academic teaching (with lectures by a teacher and assignments for the students) and traditional vocational education (with practice on equipment similar to that found in the workplace) are the best or only ways to educate adults? The purpose of this report is to present the answers that were found to this question.

The answers presented were obtained through interviews and an extensive literature review, much of it done after a thorough search of on-line databases.

Over one hundred persons were interviewed, representing a cross-section of knowledgeable people in the field of worker education and training. (See list in appendix.) These are, obviously, not all of the experts in the field, but what they had to say to us gives a reasonable picture of the state of the use of technological devices and approaches in the education and training of adult workers. From them we learned about what is and is not being done, what studies have been conducted, and we received varying amounts of detail on specifics of applications and costs.

The report is a summary and analysis of what we learned from the interviews and literature. It attempts to steer a course between the Scylla of sweeping generalizations to which we are tempted by the nature of the material and the Charybdis of anecdotal recitations to which we are drawn by the same material. To find the proper channel through these shoals, we will combine summaries of the descriptive and analytical material with critiques of their significance for understanding the state-of-the-art.

There are two important gaps in the information:

1. One results from the state of the field itself. As we shall indicate, there are few of the kinds of systematic studies that everyone would like to have that would provide a solid base for deciding what works and what does not with specific learners, to achieve specific outcomes, in specific settings and at what costs and with what benefits.

2. The second gap results from an incomplete pursuit of information that is available. We did not have the resources or time in this project to follow-up on all of the leads that we received. We believe that we have given a comprehensive overview of the current status of knowledge concerning the uses of technology in adult education and training. We know that we have not covered all of the uses of technology for that purpose nor identified all of the hundreds of programs or projects that are using various forms of technology.

We trust that this report will be useful to the staff of the Office of Technology Assessment as it explores the larger issues that constitute the context in which this study will be used.

II. TECHNOLOGICAL TOOLS.

The descriptions that follow are derived from a variety of sources: published materials, interviews, and our own experience. Since most of our information comes from particular settings, most of the description will be situation specific, with sufficient information provided so as to help determine the extent to which the experience might be generalizable to similar settings. Wherever the programs are designed to serve displaced workers needing basic skills, particular attention will be given to how and how successfully this is done.

Following each description there will be a critique of the program and some indications of its broader implications. In later sections of the report these implications will be synthesized and, where possible, generalized.

A. TELEVISION (including broadcast, cable, ITFS and video tape)

Television in its various forms is the most well-known and widely used of the newer technologies. As a broadcast medium, whether through the air or via cable, it is capable of bringing instruction to large numbers of people who might otherwise not be able to receive it. If the numbers who receive the program are large, television can be one of the least costly means of delivering instruction.

In one sense, of course, television is not an "educational technology" but only a means of delivering instruction without the student and instructor needing to be in the same location. However, in addition to being a delivery system, television does make it possible to do some things that cannot be done by a live instructor, such as enlarging images, displaying together things or events that do not occur naturally, slowing or speeding events, and, most important, permitting replication of the same content and quality over and over. For those reasons, and because television is commonly treated as a form of instructional technology, we will discuss it here.

The central feature of television is the capturing of an image electronically and either transmitting it directly or storing it on a medium such as tape or disk. Whether the image is transmitted from microwave towers, through cable, or via satellite or stored and then transmitted or displayed on a cassette or disk player does not basically make a difference so far as the content and, to a large extent, the quality of the message is concerned. However, because each mode does have some advantages and disadvantages for instructional purposes, and differing cost implications, we will discuss applications of the various forms that the television image can take.

In the 1978-79 Higher Education Utilization Study conducted by the National Center for Education Statistics, 25% of responding colleges and universities reported some use of television, but only 14% used it for off-campus instruction, where, presumably, it would have served mostly adults. During the Corporation for Public Broadcasting's first year of its adult learning service, telecourses offered by 555 colleges and universities were taken by over 50,000 students.(1)

While the focus in this study is on the uses of technology primarily for training adult workers, it is important to note the potential size of the adult learner audience. Peter Dirr from CPB estimates that, for some of the popular telecourses "there are often 100,000 informal learners (i.e., nonenrolled viewers) for each enrolled student." The numbers for "Cosmos" were approximately 10 million. "This number, Dirr points out, "is almost equal to the full-time equivalent enrollments in higher education in 1980!" Moreover, he adds, "there are 58 million persons in this country 25 years of age or older who have completed high school but who have not completed college and are not now enrolled in college."(2)

In the early days of televised instruction, numerous studies were done to compare the effectiveness of television with traditional classrooms, almost all at the elementary, secondary and collegiate levels since, in those days, television was not as yet much used for adult education. After a review of some 420 of these studies, Chu and Schramm concluded that in almost all cases there was no significant difference in learning outcomes. Differences that did show up could usually be accounted for by other factors.(3)

The judgement regarding television that we heard repeated many times is that, given a choice, students and instructors would prefer live instruction; but that if the choice is television or completely independent study, most people prefer television. For this reason colleges, particularly community colleges, have used television to reach off-campus students, who are usually adults, with a wide variety of programming. Development of adult education courses has been fostered by the Adult Learning Service of the Corporation for Public Broadcasting.

However, in spite of the potential and the activity of so many colleges and universities, there have been "glaring failures," according to Jerold Gruebel, executive director of the West Central Illinois Educational Telecommunications Corporation. He writes:

The long-running Sunrise Semester association between CBS-TV and New York University has come to an end. The University of Mid-America has collapsed. The Appalachian

Community Service network is in danger of being liquidated. The National Association of Educational Broadcasters, which fostered televised instruction, has folded. The American Education Television Network failed miserably, and the National University Consortium continues to struggle.(4)

The primary reason for these failures has been the inability of instructional television to garner an audience willing to pay for instruction via television large enough to cover the costs of production and delivery. Many of the courses offered by, for example, The University of Mid-America, simply did not get the tuition-paying enrollments that the sponsoring institutions required in order to support the programs. Often with televised courses, sponsors say that the numbers who view the courses but do not enroll are larger than the number who enroll. Only when offerings are underwritten, can such non-paying learners be served, and the institutions mentioned by Gruebel did not have enough of such underwriting to serve a general, non-paying audience.

There have, of course, been successes and some of those will be described below.

One of the leading scholars in the field of adult education, Patricia Cross at Harvard, has also examined the role of television in adult education and found that a very large proportion of colleges and universities were using television for on- and off-campus instruction. In the latter category she found, for example, that "in the profession of law alone, some sixty thousand attorneys in California are using videotapes to keep abreast of new developments in their profession." Commenting on this development, she wrote:

Thus, it may be that apologists for the instructional potential of television and video cassettes should cease their preoccupation with explaining why the media are not well received and begin to look at the potential impact of increasing familiarity on the use of media in education. As the children of the electronic age experience the use of television in schools for educational purposes, they may come to prefer it as adult learners.(5)

While a year or two is hardly enough time for aging process to occur, the results of a nationwide survey of 2000 adults reported by Aslanian and Brickell in 1980, show that only one percent of the 744 persons who said that they had done some formal study during the year were using broadcast television as a source for learning. The survey did not ask what they were studying or about other media.(6)

Another form of television is Instructional Television Fixed Service (ITFS). It is a low-power, all-directional broadcast system with a direct, line of sight reception area of about 20 miles. One of ITFS's chief virtues, in contrast with broadcast television, is that it is inexpensive. Equipment costs about \$2000 per location. Because of the weak signal, there can be many ITFS stations in the same area as a single broadcast station. Each station may have up to four channels and there a two-way audio capability which may be used for student-faculty interaction.(7)

The advantages of ITFS have been explained by Mina Ghattas and Michael Theall, director and researcher, respectively, at Northeastern University:

ITFS is a unique vehicle for the delivery of information and services to audiences whose existence has been well established (e.g.: businesses seeking specific continuing education course offerings). ITFS provides these services at reasonable cost (i.e., less than other telecommunications delivery systems with equivalent or lesser capability).(8)

Table I, reproduced from the Ghattas and Theall paper, compares ITFS with other technologies. Although arguing for the present value of ITFS, the authors foresee a time very soon when other technologies, such as interactive cable, direct broadcast satellite, and other networking systems will offer cost effective delivery systems to serve the same functions as ITFS.

Another delivery mode for the television signal is cable. Some cable companies do offer instructional programs, but as Dirr notes, "of the 4,600 cable systems in existence at the time of our study (1978-79), 80% (3,680) were six- or twelve-channel systems, which were hardly capable of providing a very wide range of services. Even in 1982, when more than 5,000 cable systems were in operation, close to 60% were still six- to twelve-channel systems."(9)

As more cable systems expand their capacities to 20 or more channels, introduce two-way capability, switch to fiber optics to improve quality and lower costs, and enroll more households, cable will become an increasingly attractive medium for instructional delivery.

Finally, there is the availability of satellites for instructional delivery. As we said above, the satellite is not an instructional technology in its own right, but rather another means to deliver the television image. However, its potential importance should not be overlooked, for reasons given by Harold Rice, vice president for Video/Audio Services and RCA American Communications:

Table I.
COMPARISON OF INSTRUCTIONAL TELEVISION FIXED SERVICE (ITFS)
WITH OTHER DELIVERY SYSTEMS.

Communications Technology	Analog circ.	Digital circ.	Real-time cap.	Easy user access	24-hour avail. ability	Multi-channel	3-way voice	2-way video	Privacy	Economic practicability rating*	Usefulness rating*	Applicability to educational, rehabilitative, medical and social services programs distribution
AM Broadcast Stations	yes	no	yes	no	yes	no	no	no	no	C	D-	Meets few of the educator specified requirements for a telecommunication delivery system.
FM Multi-plexed Circuits	yes	yes	yes	no	yes	no	no	no	yes	B	B	Useful for some applications: such as teletype circuits for the deaf; audio circuits for the blind; slow-scan TV for educational purposes.
Videocassettes/Audiocassettes	yes	yes	no	yes	no	yes	no	no	yes	B	C-	Useful as a storage medium; does not provide real-time access; has limited privacy; requires additional delivery system to reach student populations.
Public Broadcasting	yes	no	yes	no	yes	no	no	no	no	D	C-	useful only for general information and distribution; no privacy; excellent material for cultural development/enrichment programs.
Normal Telephone Circuits	yes	no	yes	yes	yes	yes	yes	no	yes	A	C-	No video, no digital capability; but useful for non-video distribution and student talk back circuits in audio-video-out systems.
Special Phone Circuits	yes	yes	yes	yes	yes	yes	yes	yes	yes	D	D-	Wide-band circuits often not available; usually costly when compared with other media circuitry.
CATV Circuits	yes	yes	yes	yes	yes	yes	yes	yes	yes	B	B-	Not available in many geographic areas; often does not have 2-way capabilities which can be costly when available.
Satellite Circuits	yes	yes	yes	no	yes	yes	yes	yes	yes	D	C-	Equip. costly, not easy to install/operate; useful for single-channel dist. in sparse settled areas. Req. 8-4 times other max frequency spectrum and dollars.
ITFS Circuits - yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	A	A-	Only available methodology capable of meeting all educator-developed system specifications.

From J.A. Curtis, "Instructional Television Fixed Services: A Most Valuable Educational Resource." In J.A. Curtis and J.M. Biedenback, eds., Educational Telecommunications Delivery Systems (Washington, DC: American Society for Engineering Education,

*A+Good B=Fair C=Poor D=Not useful

Education and training by satellite is a national resource. No other distribution tool theoretically can reach the entire nation (he might have added: and the world) at such a low cost. But at the same time, we must realize that corporations will accept the satellite as an education distribution method only if it proves economically justifiable. And we must realize that employees will only accept satellite-distributed material if it is part of a professionally prepared and delivered package of learning.(10)

While the numbers that can be reached by a live broadcast is theoretically very large, scheduling often limits the numbers who actually view any presentation. The numbers reached can be increased by using video tape or disk. These modes allow students to use the material on their own schedules and to stop, start and replay segments at will. Disk and tape do require equipment that is not always available to adult learners.

Adult education has seen the full range of applications of television. The simplest use has been to put one or more cameras in a regular classroom and distributing the unedited result either directly over the air or via tape. At the other extreme there have been the elaborate course productions of the BBC, the British Open University, and those being funded by the Corporation for Public Broadcasting.

We have not attempted to identify all of the uses of television to meet the learning needs of adult workers but only those where it is being specifically used for displaced workers, or is making what appears to be a unique contribution to solving common training problems, such as in the continuing education of field engineers. The following are examples of some of the applications that we found:

Wayne State University.

One of the most extensive efforts to serve displaced workers via television has been the College Cable Network Project, a collaborative venture of Wayne State University and WTVS in Detroit, Michigan. The United Auto Workers was actively involved in the development of the program.

Started in 1973, the original concept of the project was to provide opportunities for working adults to earn college degrees without having to take long periods of time off from work. Courses were designed to be delivered via television and through classroom sessions conducted on week-ends, which resulted in the program being called a "Week-end College." Initially there were only 80 full-time students enrolled. Some 15,000 workers have taken courses and over 2000 have graduated. The

students have to meet the same examination and other requirements as regular college students. Currently there are 400 students enrolled full-time and 1000-1500 part-time in credit courses.

In addition, this fall, the program is seeking to reach some 4000 unemployed workers, many on welfare, to encourage them to use Pell Grants and tuition grants from the automobile companies to which they have access, to enter the degree program.

When the heavy layoffs hit the auto industry the focus of the program shifted somewhat from a degree emphasis to meeting some of the more immediate information needs of displaced workers, such as for information on job availability, career planning and skill training. This program was developed by the College Cable Network of Channel 56 in Detroit.

This program provides job orientation and support for several thousand workers using cable television on a 24-hour a day basis, with opportunities for students to come to learning centers to meet with instructors and each other. Delivery of material for broadcast on the many cable systems involved in the project is via IFS. This is done to keep distribution costs to a minimum.

In 1978 other colleges were invited to join the program. The To Educate the People Consortium was formed which now includes more than 25 institutions. Courses are delivered via satellite to them. "The Consortium offers baccalaureate degrees, with special emphasis on topics of special interest to workers, such as the history of unions, economics, and organizing strategies. Much of the material use was developed by Wayne State.

Discussion.

No systematic study has been done of the students in the program in comparison with traditional students. However, project administrators claim that there are no indications of differences in learning or retention although they do say that regular contact with faculty seems to be a key factor in student retention. Providing such faculty contact does significantly increase the costs of the program and reduces the cost advantage of television delivery. In order for the program to be cost-effective there must be large numbers of participants; to achieve large numbers there must be constant effort on the part of program administrators to make the program known to potential participants.

A key to the whole effort, according to director Otto Feinstein, is changing the culture of the workplace so that both workers and employers support the value of continued learning.

However, Feinstein argues, even if the costs are high, the critical question is the value of providing educational opportunities to people who would not otherwise have them. In his view, it is not the technology, but the provision of accessible opportunities that is key to meeting the needs to workers both before and after they have been displaced.

Today the entire operation of the program is funded out of tuition income. One of the battles with the University that he had to fight, says Feinstein, was to retain all tuition income for the program. "Only in this way can programs that serve non-traditional students become self-supporting."

Oklahoma State University.

The use of television by John Jobe at OSU is very different from the Wayne program. Jobe uses video tape to provide remedial tutorial instruction on specific math problems that students encounter during their courses. The programs are not course lectures, they are tutorials. The students use them on an independent, voluntary basis only when they need to learn how to do something that they did not learn during the regular classes.

The tapes are produced by videotaping actual tutorial sessions. With each tape there is supplemental print material which the student is expected to use.

Jobe has produced over 300 thirty-minute tapes with accompanying print materials. They are available to students on campus in the TV lab and are, according to Jobe, heavily used. They are particularly welcomed by older students who often have trouble with some of the math concepts that come more easily to younger students.

The cost per module is highly variable but averages about \$1000.00.

Discussion.

Jobe has not done any systematic study of the effectiveness of the modules. He relies on the indications of heavy student use to establish that this use of television is effective. As a further indication, the publisher, Addison-Wesley, is having Jobe produce tapes as a supplement to a new math textbook.

ITT Telecom.

A somewhat similar application of television is used for worker training by George Harmon, Director of Personal

Development at ITT Telecom. Here television is also used for tutorials but, in this case, the production of video tapes is more elaborate than at OSU. When a training need is identified, Harmon selects an appropriate subject-matter specialists either from within the company or outside. The expert conducts a tutorial with one student. Three cameras from differing angles capture images of the session. Those tapes are "source documents" from which a final tape is prepared. If the content is acceptable but the presentation is not, a professional actor may be used to produce the final tape.

Discussion.

Harmon went to this approach because his experience in training had shown that while one-to-one tutoring was by far the most effective training method, it was also the most costly. The taped tutorial enabled him to capture the expertise of the content specialist with a minimum cost in time and money; while the editing and remake allowed him to produce an effective instructional program that would be used by the people for whom it was intended. The intended users are in plants throughout the world which would have made bringing the specialists and the students together prohibitively expensive.

This evident advantage is so great that Harmon sees no need to compare the results of the video taped with regular instruction. He does, however, claim that users of the tutorials can gain as much as students in classes in one-fourth the time.

University of South Florida.

The College of Engineering, like other engineering colleges (Stanford, Northeastern, University of Massachusetts), has recognized the need of practicing engineers for continuing education. Because these people cannot easily come to campus, the college delivers courses to them via ITFS and tape. Over ITFS the courses are beamed live to remote sites in the Tampa area. There is two-way sound so the students at any location can interact with the instructor.

For those that cannot meet the live schedule, the same material is distributed via tape but without, of course, the opportunity for immediate interaction.

However, even in the live remote locations, there are limitations on the amount of interaction that can occur between students and instructors. For example, it is difficult for instructors to know how students s/he cannot see are responding to the lectures. To overcome the problem, Dean Andrew Barrett and his colleagues in the College of Engineering have devised a "magic box" that permits an instructor to get the same feedback

from students regardless of whether they are in the classroom or at a remote location. The box is connected to each student location by telephone. When the instructor asks for a response, each student enters his/her response on a keypad. The results are instantly displayed to the instructor, who can then see if there are any differences in response that are dependent upon location of the students.

The same system can be used to distribute quizzes and transmit homework from the students to the instructors. In the latter application, the students do their homework on computer disks, which are inserted in a transmission device at each location and sent to the instructor's machine. There s/he can correct it and return it via the same channel, thus greatly reducing turn around time and paper handling. An addition being worked on would enable students to use the system even if they are receiving the course via tape rather than live.

Barrett hopes to see this system used in all remote locations by January, 1985. "Such a system," he said, "assures delivery of high quality instruction to any business site in the State. This," he emphasises, "is an important factor in drawing high technology industry to the State."

Discussion.

"I would prefer live instruction," said Barrett, "but, since that is impossible, television is a better alternative than nothing. It is critical that we provide opportunities for continued learning for our engineers whose knowledge becomes obsolete in 4-5 years."

To make remote delivery cost-effective Barrett needs to increase the numbers being served. To achieve that objective, the college has formed a consortium with other institutions in the State and hopes to do the same on a nationwide basis. They would like to create a satellite network with full two-way capability, but up to now the cost of transponder time has been a barrier.

Northeastern University.

In 1983 Northeastern began using ITFS to deliver graduate level engineering courses to professionals in Massachusetts and New Hampshire. The courses are sent during the day to nine area electronic and electrical companies at 13 sites. The service offers one-way video and two-way audio which allows the students at remote locations to communicate with the faculty. This year the service will be delivering 80 courses.

The University has joined with 14 others to form The National Technological University (NTU). The NTU offers

televised courses in computer engineering prepared by seven of its members. Among the courses which will be offered for the first time in Fall 1984 are Software Engineering, Error Correcting Codes, Advanced Computer Architecture, Introduction to Artificial Intelligence and Interactive Computer Graphics. Participating universities in addition to Northeastern are Colorado State University, where the headquarters for NTU is located, Purdue, Georgia Institute of Technology and the Universities of Maryland, Massachusetts, Minnesota and South Carolina.(11)

Discussion

See the discussion of ITFS above.

City University of New York.

Concern with students who are place bound because of limited mobility or limited resources, Lee Cohen, Director, Institute for Research and Development in Occupational Education, has looked at low-power two-way television as an inexpensive way to bring courses to people in a geographically limited area. The basic equipment for broadcast purposes is only about \$1000. By creating a network with other colleges, resources could be shared and people served who would not otherwise be.

Discussion.

In spite of the low-cost and ease of use of low-power television, Cohen has not yet been able to get anything but very limited experiments started.

Army Health Services Command (HSC).

The HSC at Fort Sam Houston, Texas, has used a satellite since 1979 to help educate personnel around the world. Two daily network programs are broadcast on various medical subjects. One is directed toward enlisted personnel, the other to professionals such as doctors and nurses. The programs include two-way telephone communication during the live broadcast.(11)

Discussion.

This program illustrates the capability of using satellites to reach people widely dispersed over the nation or the world. The report did not, however, indicate how the program handled the time-zone differences, particularly during the interactive portions of the program. Given the costs of satellite transmission and the limited availability as yet of ground receivers, it may be that only the military can afford this system at the present time. It is to be hoped that studies

are being done of the effectiveness of live and two-way transmissions in comparison, for example, with the use of tape or disk for distribution of the basic material, with audio conferences occasionally to get the two-way interaction.

B. VIDEO DISK.

We treated video tape as an extension of broadcast television because, essentially, it is a linear presentation mode with only limited opportunities for student interaction. There have been systems developed to permit random access to tapes but these systems are cumbersome in comparison with the video disk.

Ever since the development of the video disk in the early seventies it has excited many educators looking for a technology that would combine the visual power of television with the interactivity that they all recognized was missing from broadcast television. Yet in spite of the apparent promise of this technology, the promises have yet to be met. In looking for technologies that work in education and training, this example is particularly instructive.

The features of video disks that have excited educators about its potential are:

1. Random access capability. Any frame on a disk can be found in under five seconds. (In contrast, the maximum search time on a thirty minute tape can be 3.5 minutes.) This means that all of the information on the disk can be accessed by the learner or by a computer program that selects the next frame to be displayed based upon the student's previous actions.

2. Information density. A single side of a disk has 54,000 frames, with sufficient resolution so that each frame can present readable written text or very high quality graphic or pictorial images. (The resolution is 350 lines per inch in contrast to tape's 250 lines.) Viewed at the rather fast rate of one image per second, it would take 15 hours to view all 54,000 frames. This means that a huge amount of visual information can be stored on a single disk.

Because of the density of the storage on a disk, if textual rather than visual information is recorded, the entire text of the 30 volume Encyclopedia Britannica could be stored on merely four percent of the disk's surface. The disk really should be thought of as a convergence of all media, not simply as a videotape on disk. (13)

3. Durability. Because in laser disk players there is no physical contact with the disk, there is virtually no wear. The disks themselves are made of durable materials that are relatively impervious to abuse.

So promising was this technology that one of the earliest developers, Alfred Bork, Director of the Educational Technology Center at the University of California at Irvine, in the early seventies dubbed the combination of the video disk and the computer as the "intelligent videodisc." (14)

In 1977 Andrew Molnar and Dorothy Deringer of the National Science Foundation reported on a conference organized by Bork on "Intelligent Videodisc Systems for Education". While suggesting the great potential for education, they concluded that "preliminary research and development is needed before judgments can be made as to the significance of this technology in education." (15)

The most recent survey of the implications of the video disk for education cites numerous endorsements of the wonders of the disk, concluding with the view of R.K. Wood and R.D. Woolley in a 1980 NIE report that, "The impact will be equal to or greater than that of print technology some 500 years ago." (16)

In spite of the potential of this technology and the enthusiasm of its proponents, it has yet to make a significant impact in education or training. To be sure there have been interesting applications. Ford and General Motors provided disks and players to each of their dealerships for use by salesmen, customers, and mechanics. (17)

The Defense Department has developed video disk-based simulators and used them in tank gunnery training, flight simulators and maintenance training. (18) JAM, Inc., a video disk production firm in Rochester, NY, has produced interactive disks for Wang, Kodak and Rochester Institute of Technology. WICAT, a development organization in Urem, Utah, has made extensive use of interactive video disks in its training programs for industry. We did not encounter any applications of video disks in remedial education.

One of those industries is ART Information Systems in Parsippany, NJ. Al Cohen, director of the Service Division, described the three modes in which they have been using interactive video:

1. Full motion and sound. The only student control is starting, stopping and moving about in the program.
2. Still frames with text. Here there are "maps" on the screen so that the student can move around to find just the portion required.
3. Pages of text only as source documents. With an index accessing system, this provides information only when needed.

Cohen says that thus far they have only done informal studies but they seem to indicate that interactive video disk programs "cut teaching time by 50%."

The International University Consortium for Telecommunications in Learning (IUC) has released the findings of a 1983 Videodisc Feasibility Study. The evaluation showed that the technology is a cost-effective alternative distribution system for the video components of IUC courses. It is feasible as an alternative means of program distribution as well as being a valuable teaching aid for faculty.(19)

Despite all of the apparent advantages of interactive or "intelligent" video disks and the interest of many developers in their use, Cynthia Schuyler reports that "in many training and educational circles, the new technology, initially hailed as the ultimate training medium, was branded as a loser." The reason according to Schuyler and many others is cost. An interactive playback system costs between \$2000 and \$15,000 and production costs for a single disk can run from \$50,000 to \$400,000. (See below, Chapter X, for a further discussion of cost factors in video disk simulations.)(20)

Another factor is the interaction of the availability of playback equipment and courseware. People won't invest in the equipment unless there is something useful to do with it; courseware producers won't invest in development unless there is a market for it. Schuyler's sources, especially a report from a business research firm, suggest that 1984 may be the year when the "critical mass" on both ends comes together.(21)

However, it may not be just cost and the hardware/courseware connection that has prevented full development of this medium. As Molnar and Deringer said back in 1977, "research and development is needed" and not much of that has yet occurred. Further, as Schuyler discovered, "from the point of view of trainers themselves, the promise offered by interactive video is still not altogether convincing." (p. 9) The problems are those that this medium shares with computer assisted instruction and, indeed, with any technology that attempts to replace the personal interaction of student and teacher with a non-human device. We will have more to say about these problems below.

University of West Florida.

The University of West Florida has been working since 1981 to develop a 160-hour training program for newly hired employees of the Florida Health and Rehabilitative Services. The program consists of nine video disk sides, 78 floppy disks, and eight reference manuals. Development costs approached \$1 million not counting start-up and learning expenses.

A pilot test of the materials was done in 1983 with 13 candidates. They were positive about the training, which reduced instruction time 25% over classroom training. Trainees consistently scored 15-25 points higher on the final examination than did classroom trainees.(22)

Discussion.

This example is a further illustration of a point made many times in this report, that the studies of the new technologies are too limited as yet to provide a basis for decisions regarding their effectiveness and utility.

Another very critical point suggested by this example has to do with development time and costs, and the time that will be required to bring the development to a cost-effective level. According to the report, the program has been in development for some three years and cost nearly \$1 million. The question has to be raised as to how stable the training requirements were over the development period, and, even more, how stable they will be during the time the program must remain viable if the program is ever to become cost-effective. The report notes that 500 employees will be trained in 1984. That puts the cost for development only at \$2000 per trainee. To bring that cost down say to \$200 per trainee would take, at that rate, ten years of training. In today's world it is unlikely that any training program can (or should) continue to meet needs for that length of time.

Of course, if the reductions in instructional times and improvements in learning remain consistent as the program is implemented, the development costs may be more than recovered in a much shorter period of time. The critical question is how valuable to the organization are the time saved and the increased levels of learning.

C. COMPUTERS.

In education computers can be the subjects of instruction, as in courses on "computer literacy" or programming; they can be used as tools for accomplishing tasks in which there may be a great deal of learning occurring, as in their use as word processors in writing courses or as design tools in many areas using graphics; they can be used to deliver instruction either prior to application (Computer Assisted Instruction — CAI) or at the time and place of application (Embedded Training); and they can be used to manage instruction (Computer Managed Instruction — CMI). It is only as deliverers and managers of instruction and that computers will be considered here.

1. Computer Assisted Instruction.

In Chapter XII we will give a brief history of programmed and individualized instruction, two efforts to develop a technology of instruction that preceded the development of computer-based instructional technologies. One of the first persons to attempt systematically to develop the instructional uses of computers was Donald Bitzer at the University of Illinois. In 1960 he began the development of what was to become the PLATO system. Large grants from the National Science Foundation, the Office of Naval Research, the Defense Advanced Research Projects Agency, the National Institute of Education and private foundations provided funding for the developmental phases. According to Marc Tucker, director of the Project on Information Technology and Education, about one billion dollars have been invested in the development of PLATO since its inception.(23)

In 1963 Control Data Corporation (CDC) began a cooperative venture with the University and in 1967 it assumed full responsibility for the marketing of the system. CDC and the University have just announced a "third generation" partnership agreement for on-going research and development of PLATO. (24)

The full PLATO system runs on a time-shared basis from a large CDC mainframe which can support over 1000 terminals. The PLATO terminal contains a touch-sensitive display panel and keyboard, and can control various multi-media devices. Communication is via a CDC network or networks of the user organizations. Some of the PLATO software has been reprogrammed to run on CDC's own and other microcomputers, but because of the more limited capabilities of the micros, some features of the full PLATO system have had to be sacrificed, including most of the management functions. The software includes an authoring language, over 8000 hours of courseware and a management system.

Because of its long history and because it is one of the most widely used CAI system for adult learners, we use it here as the illustrative example of CAI.

In the area of adult basic education, PLATO is being used in settings such as in a downtown, urban, community center in Charleston, S.C. run by the National Center for Work and Learning in Washington, DC, and a local community college. It uses PLATO to provide basic skills courses in remedial reading, mathematics and language arts for youth and adults, 58% of whom are employed full- or part-time. Preparation lessons for the high school equivalency examination (GED) are also available. (See Chapter VI for a description of another program run by Central Piedmont Community College in Charlotte, NC.)

In Washington, D.C. PLATO is used for GED preparation in the federally-funded Educational Opportunity Center located in the Anacostia section. In Baltimore, ABE courses and GED preparation lessons are used by older adults at the Waxter Senior Center, where PLATO computer terminals are available. Many of the older people are also seeking jobs and find that receipt of the GED is a job-hiring prerequisite. Complete data on adult participants in these ABE projects is not available.

Another use of CAI as demonstrated by PLATO is as a tool for broad career planning and exploration. Adults facing career changes or job displacement can use PLATO's career-guidance courses to learn how to evaluate personal and professional needs and capabilities, how to research the job market and how to plan long- and short-term goals. These CAI materials can be used wherever PLATO is available — in colleges and universities, in business and industry settings, or in CDC-sponsored Learning Centers located in nearly 100 cities across the U.S. where, for a fee, anyone can use the PLATO materials. CDC does not have participant data for these PLATO courses.

Since 1978 CDC has used PLATO as the major component of "Fair Break," a program developed to attack the causes of chronic unemployment. The computer is used for remediation in basic skills, for high school equivalency instruction, and for development of "life management skills." There is also a training course for program staff called "The Helping Relationship."

CDC claims that Fair Break is "at work in more than 50 agencies nationwide" but gives evaluation data from only three programs. They show high school equivalency completion rates of 92.6% and positive program terminations at 76.3%. (See Chapter VI for further discussion of the uses of PLATO in remedial education.)(25)

PLATO as a CAI system also permits a variety of vocational training applications where broad job-related skills can be learned by persons seeking employment in specific fields as well as those workers already employed. Companies use PLATO to provide vocational training. For example, Motorola, Inc. started a pilot program in 1982 using PLATO at its Franklin Park, IL plant. The CAI system is used to teach employees basic and advanced electronics.

Individuals who wish to start their own businesses can use PLATO in CDC Learning Centers, where more than 100 courses created for small enterprises in such areas as how to establish and manage a small business, accounting and selling, purchasing, and government regulation are available.

The military services have used and evaluated PLATO in a number of locations. Jesse Orlansky and Joseph String of the Institute for Defense Analyses in Arlington, VA, have done a comprehensive analysis of the military use of PLATO and other computer-based instructional training systems in the most thorough treatment of training technology of any that we have encountered. We shall discuss their assessment of PLATO and other systems in Chapter V.(26)

The Army, through the Army Research Institute and a contract with Florida State University, is developing the use of PLATO and other CAI systems with authoring capabilities to train Army personnel in basic skills and learning strategies deemed necessary to perform tasks required for Army job grades E1 through E5. Florida State is midway through this large curriculum development project at present. A CAI system such as PLATO was utilized, according to Army personnel, because the resulting curriculum will provide uniform instruction to a wide variety of military personnel scattered across many sites. Previously the Army had relied on individual instructors and, as would be expected, the quality of the resulting instruction varied with the capabilities of the individual teacher. The use of CAI permits standardized instruction levels unable to be achieved with individual instructors, the Army believes.

Actual and specific job training is also provided using CAI systems like PLATO. For example, 112 GM plants are using PLATO to help retrain workers to maintain new types of automated equipment. The on-the-job training includes basic electronics as well as diagnostic and trouble-shooting techniques. CAI systems can then be used in dislocation prevention programs and help workers to develop new skills for new jobs and new equipment. In many cases, instructional designers work closely with production people so that when the new equipment is introduced, the instructional material is ready. General Electric is setting up training stations using PLATO on the shop floor — a close merger of CAI-supported training and work.

In these examples of PLATO as a CAI system, the computer is not the sole device utilized. PLATO relies on mixed media, including text, videotape, video disk, audiotape and other tools depending on the requirements of the particular course. There is often an instructor or aide at the site to help with problems, provide encouragement, or just be available to provide a human presence. Rarely does one find use of a CAI system for education and training of adults that relies solely on computer use.

In industry and the military, the two components of PLATO that are reported to be used even more than the library of courseware are the instructional management system (see next section) and the authoring language. The authoring capabilities

differentiate PLATO from many other CAI systems, permitting local sites to develop their own courseware. The TUTOR authoring language "contains over 250 commands which fall into five large groups: display, calculation, branching, answer judging, and data collecting". It includes "templates" - a subset of the authoring commands, which, it is claimed, enable subject matter specialists with no training in instructional design to develop usable, individualized instructional programs. These templates are being used increasingly to produce customized materials to meet specific and, often, rapidly changing training needs.

In later sections, we will discuss the advantages and disadvantages of PLATO and the computer generally as an instructional tool and the information available regarding effectiveness and cost effectiveness.

2. Computer Managed Instruction (CMI)

The individualization of instruction puts a heavy record keeping load on the instructor. Keeping track of each student's progress through the differing possible paths in an instructional program and being sure that the right lesson and material is assigned at the right time is a formidable task. The computer's huge and rapid data management capabilities have helped solve this problem through computer-managed instructional systems.

Because of computational and data storage requirements, most CMI systems have in the past been designed to operate on minicomputers or mainframes. However, with the growing capacity of microcomputers, CMI systems are being designed to run on them as well. The computer that contains the management system, is often networked to microcomputers through which instruction is provided and from which information is obtained for monitoring purposes. Instructional programs provided on "stand alone" computers usually do produce records of student progress.

It is not, however, necessary for students to receive instruction from the computer in order to have CMI. All that is necessary is that there be some way to input information about student learning activities. When the student is receiving instruction on the computer the results of that activity can be entered automatically into the student's record. When the student works away from the computer, test results or other information about student progress have to be entered into the computer in some way.

Each time information is entered, the student's record is updated and available for retrieval. That retrieval may be by students, instructors, course designers, and program administrators. The nature of the information that may be

obtained and the simplicity or complexity of reporting formats are determined by the system designer. These may range from simple reports on the class grades on the latest examination to detailed reports on each student's progress on each of hundreds of learning objectives, including comparison of each student with the class as a whole, all the student's in a program and nationally established standards.

In well-designed CMI systems instructors, course designers and program administrators can not only get information organized in any way that is useful to them, but they can manipulate the information to get answers to questions that will help them improved course design or delivery and program management.

CMI helps students keep track of their own progress. If they are using the system to receive instruction, each time they sign on the system starts them at the point they left off the last time. Through diagnostic tests, the system can determine what the student knows and need not study and what s/he does not know and needs to learn. Thus learning time is conserved and students avoid the boredom of repeating lessons already mastered.

Whether or not they are receiving instruction via the computer, students can get information about their performance that is helpful in their own self-diagnosis. This is one of the powerful ways in which the computer helps put control of learning in the hands of the learner, a factor that is particularly important for many adult learners.

This ability to monitor instruction was cited as one of the strongest reasons for choosing Control Data Corporation's PLATO system by the University of South Florida, Ohio State and the Centers for Disease Control, and by the Niagara-Orleans Board of Cooperative Education Services in up-state New York for choosing the basic skills system from Computer Curriculum Corporation (CCC). Both of those systems have an instructional as well as a CMI component.

Another approach to CMI is the Camelot system developed by Miami-Dade Community College. Only a management system, it provides a highly flexible framework that allows any instructor to design a management system for his/her own course. The feedback from the system can include detailed analyses of the student's performance as well as prescriptions for further study to correct weaknesses or progress to the next set of learning objectives. This system has recently been reprogrammed to run on several widely available microcomputer systems which, of course, lowers its costs and increases the numbers of institutions that can make use of it.(27)

Examples of CMI systems in use by the military are:

- Army: Automated Instructional Management System (AIMS)
Field Artillery School, Fort Sill, OK.
- Navy: Computer Managed Instructional System, Naval Air
Technical Training Center, Millington, TN.
- Air Force: Advanced Instructional System (AIS), Air Force
Technical Training Center, Denver, CO. (28)

These systems can handle large numbers of students: for example, AIS can support up to 3,000 students a day in four courses. In this arrangement the instruction does not occur at the terminal. The student's test answer sheets are read into the computer from an optical reader and the student receives a printout which tells him how well he performed, what lesson to do next, and where to find it.

One of the great advantages of CMI is that it reduces the record keeping burden for instructors. All of the data is automatically entered into the system and can be retrieved on demand in many different ways. Where CMI does place a greater burden on instructors is in making meaningful use of all of the data that is available. Without proper training in the use of the data, instructors can become so overwhelmed with the volume of data that they either give up on using it entirely, or spend excess time trying to make sense out of it.

Like all of the other technological tools discussed in this report, CMI is no panacea. To be an effective tool, its use must be carefully thought through and it must be integrated into a total instructional system.

3. Embedded Training.

The newest application of computers to instruction is in the form of what has come to be called "embedded training." Embedding means the incorporation of training within the work process. Instead of learning prior to and at a different site from work, embedding makes training available when needed at the place and usually on the machine where it is to be applied.

We first encountered the term "embedded training" in our interview with Joe Harless, one of the leading consultants in the field, and thereafter encountered it or accounts of the phenomena so many times that we became convinced that it is an important trend in the nature of training.

The movement toward embedded training is being driven by a number of forces in contemporary technology which would seem to insure that this practice will become widespread in a wide

variety of work settings. Chief among these forces are the increasing capacity of microchips, their incorporation in more and more machines, the speed with which new machines are introduced and their high reliability of most chip-based devices.

As the microchip with its increasingly large memory capacity is incorporated into more and more devices, it becomes cost-effective to embed instructions in the device itself on how to use it. Most devices that use microchips now include diagnostic circuitry that speedily identifies any malfunction in the equipment.

At the same time, equipment life is getting shorter. At Western Union International, according to Bruce Ingraham, Director of Training, equipment used to last twenty years or more. The "life expectancy" of the training to use and repair such equipment was therefore long enough to justify high initial investment in training. Today equipment remains in use five years or less. It has become too costly to train workers in the traditional way every time a new machine is introduced. Even with the cost of producing the embedded training, it is being found less costly to do the training that way rather than ahead of need.

WUI has, therefore, gone to embedded diagnostics and training, thereby reducing both the pre-service training time and the time at the work site to do the job. "Look and swap" is the way that Ingraham characterized the practice of reading the diagnostics, taking out the defective component and inserting a new one. The defective part might be thrown away if it was more costly to repair than to acquire, or sent to a repair facility if it was repairable.

A further extension of this approach, reported by NCR and AT&T, is the use of remote diagnostics and repair. This is possible when the operational system is in software and devices are connected to communications systems.

Because of the increasingly high reliability of most solid state, high tech devices, they can go for long periods without any operator intervention. Also, most machines now have such large numbers of functions that many of them are only used infrequently. (Think of the functions built into newer word processors in comparison with those available in earlier models.)

When tasks are performed only infrequently workers often forget much of what they are expected to know in order to perform the task. Rather than provide frequent refresher training which still may "decay" before use, it has been found more effective to make the necessary information, including modeling of the necessary behavior, available on a "when needed" basis at the point of use through embedding.

where once word-processors computers and computer software were accompanied by large and, often, incomprehensible user manuals, increasingly the user guidance is being "embedded" in the devices or on the disk in the form of job aids that are available when one needs to know how to perform a particular function. This same approach is being applied throughout the world of "high-tech" in CAD/CAM machines, in communications switches, in military hardware, and now even in consumer products.

In the continuum of devices used for embedded training, the one closest to "reality" is when the device used on the job is also used in training. In effect, the tool itself also becomes the training device. Much of computer training is now of this nature. One of the most interesting applications of this approach is the word processing training program developed by Manpower Services.

Five years ago Manpower faced the problem that is now becoming endemic throughout the entire economy: how to train employees on new technologies as they come along and do so in a cost effective manner. They saw that with changes in office equipment they could no longer expect to send a person with typing skills into an office and have her able to go right to work. They needed to train temporaries to be able to handle Wangs, Xeroxs, IBMs or whatever might be encountered. Moreover, since their employees tend to stay with them for only short periods, they could not afford to invest a large amount in their training.

The company went through an extensive search to find a training system that was fast, effective and cost effective, one that would work with large numbers of people in dispersed locations. They first tried the training programs and manuals supplied by the equipment manufacturers, but found them to be written in a language and at a level of complexity that was inaccessible to their people. They examined many packaged training programs, but found that all of them tried to teach far more than they felt was necessary in order to begin to use a machine.

One of the key difficulties was that none of the programs was written from the operator's point of view in language that was ordinarily used by secretaries. Because of their difficulty all of these programs tended to increase the fears of the learners, which were great enough anyway.

The company then undertook a systematic analysis of the training problem to see if they could devise a solution that would meet their requirement. Here in summary is how the analysis went, according to Manpower President, Mitchell Fromstein.

A. PROBLEM: Language of the manuals was too difficult and not related to that of the users.
SOLUTION: Rewrite manuals in "secretarial language".

B. PROBLEM: Most of trainees had been out of school for a long time and were not accustomed to long training sessions.

SOLUTION: Make short training modules, put them into the machine that is the subject of the training and personalize them. This was done by producing the revised manuals on a disk for the machine that was to be learned. Each segment is short enough to appear on a single screen and focuses on a specific function of the machine that the operator "needs to know" in order to operate it. (They got rid of all of the "nice to know" or "what to do if" stuff that fills so much of most manuals.)

C. PROBLEM: Many trainees are fearful of the new machines and their impersonality.

SOLUTION: Using the global search and replace feature of the machine, they put the student's name at appropriate points throughout the lessons, thus making the learner feel that the training was really addressed to her.

D. PROBLEM: Many trainees have doubts about their ability to master a complex new machine. The resulting stress inhibits learning and reinforces their feelings of inadequacy.

SOLUTION: The training is given in a tutorial setting with a trained supervisor present to get the trainee started. The trainee is shown how to insert the disk, turn on the machine and call up the first screen. At the point the program takes over and begins by showing the student how to move around in the training program.

Both the supervisor and the program tell the student that there is nothing they can possibly do that will hurt either the machine or the program. Since the procedures being learned to move around in the training program are regular word processing functions, the student begins learning the machine from the very first key stroke. The discovery that they can control the machine almost immediately lowers the stress level and increases learning rate.

E. PROBLEM: How to know if the trainee has mastered the program to a sufficient level.

SOLUTION: At the end of training disk, the trainee is asked to compose a letter to the president of Manpower about the training program. Successful completion of an acceptable letter is viewed as a valid performance test. Fromstein has over 14,000 such letters, many with suggestions for improving the program. Since the disks are themselves "documents" produced by word processor, it was easy to make corrections and improvements, making the version in the field always the latest one.

In addition, Manpower has a paper and pencil screening test to determine if persons seeking employment have the skills they claim and at what level. The trainees are given that test at the end of the training and must meet the same standard as any person who is hired by the company.

F. PROBLEM: Because trainees often do not get assignments that allow them to use their new skills, account has to be taken of the decay of learning if skills are not applied immediately or regularly.

SOLUTION: They allow the trainees to return at any time and go through disk again. Usually less than an hour is sufficient as a refresher. They have also created an "operator support manual" which is a small, purse-size version of the material on the training disks. It is carefully indexed by the kinds of terms and functions the user would want to reference, with "screens" reproduced exactly from the training disks. Furthermore, there are even color coded instructions so that the function can be performed "by the numbers".

The result of this effort, Manpower claims, is that a person who has never used a word processor can learn enough to go into an office and function effectively in 8-15 hours of training. Most do this in one day, some take up to a full second day. After working for about two weeks on a first system, a person may come for advanced training on the first machine or for training on a second system. To learn a second system takes usually less than half a day because the focus of the initial training is on functions, which do not vary much from system to system.

Manpower invested \$6 million in the development of the training program. It hopes eventually that the cost per trainee will work out to \$30, which makes this very competitive with word processing training programs available elsewhere. Moreover, Manpower charges customers 20-25% more for a word processor operator than a typist, so that increased profits will also be generated by the investment. In addition, Manpower has adapted the system to teach software such as Multimate, Lotus, and Visicalc and is adapting it to do training for networked environments.

Other software producers are also moving to embed training in their packages. William H. Gates, one of the leading software developers and now CEO of Microsoft Corp., Bellevue, WA, recently said: "Over time we expect to include CAI with every one of our applications packages. That is something the entire software industry is pushing towards because it is so crucial."(29)

In contrast to Manpower, Kelly Services, another temporary services provider, has developed a word processor simulator which allows training for differing word processing machines all to be done on one machine. JAM, a training company in Rochester, NY, has an intermediate approach: it has a video disk training program that works in tandem with a Wang Word Processor.

No one has done a nice comparative study of these three approaches and it is doubtful that a truly valid study could be devised. In each case, the test of whether the approach selected is effective will be in the performance of the trainees when they are out on the job. Each company monitors on-the-job performance and know very quickly when problems with its training approach arise.

As to the cost-effectiveness of the approaches, that is highly dependent on a great many variables, as we will show below when we discuss this topic.

The movement toward embedded training has profound implications for many aspects of employment and training:

1. Far less training needs to take place prior to employment or prior to assignment to a specific task. This may reduce the cost of training.

2. With embedding it becomes possible to shift certain key operations from employees to customers. One of the most visible manifestations of this development is the Automated Teller Machine. The next step in this evolution is going to be to move the teller function into the home. Indeed, as the "technology of embedding" improves, the skill requirements on the part of the end-user decrease to the point where vendors are now shifting the responsibility for installation and maintenance to the user. "Plug and Play" is the slogan at NCR, according to John Morohl, Director of Technical Training, which means that even complex machines are now delivered to the users without the necessity of having field staff come out to install them.

3. Because embedded training is best done while the device or process is being designed, increasingly instructional designers are being brought in as part of the product or service planning and development team. This collaboration between machine designers and trainers is one of the strong trends that has emerged in our research.

D. SIMULATORS.

Simulators are devices which duplicate the behavior of real-life machines (like ships or airplanes) or complex systems (like subways and power plants). Orlansky and String have done a

study of simulators in the military very similar to the study referred to above on computers.(30)

Simulators differ notably in their resemblance to actual equipment, their functional capabilities as instructional devices and in their complexity and cost. They are either two- or three-dimensional. The 2-D devices display the simulated device or system on a panel. The student responds to the situations presented, which are selected by the instructor or the program. Simulators perform as if they were real equipment because each contains a computer with a mathematical model of the real system.

Simulators are attractive as training tools for a number of reasons:

1. They enable a trainee to accumulate "hands-on" experience without the danger and expense of damage to an actual machine or system.

2. They accelerate the rate of learning since many training occasions can be provided in much shorter time than in the real situation. As Judith Robinson, marketing manager for Digital Technology Center says,

Simulators in many cases provide the only solution to training problems that are too costly or dangerous to create in an actual process situation. Without simulators trainees cannot be prepared for such things as equipment failure because firms cannot afford to let equipment fail and then let a process run its course.(31)

3. They can provide a larger variety of malfunctions than would be possible to have occur easily on operational equipment or systems.

4. They are generally less costly to produce than actual equipment.

5. Records of student performance can be maintained automatically, thus giving instructors more information about performance than possible on actual equipment.

6. Students appear to take less time to learn on simulators.

7. Another role for simulators is in "on-demand" training situations. In increasing areas of technology the time between failures is getting so long that maintenance personnel go for long periods without ever seeing particular events. Rather than giving them training that they will probably have forgotten when they need it, designers are providing when needed maintenance training. When a failure occurs, the technician goes through a simulation of the problem to be solved.

Simulators are programmed to respond to student input in as close approximation as possible to the way the real device would. Link Pilot Training Simulators are one of the best known such devices. Other examples of the applications of simulators are in the training of:

- a. Merchant seamen in docking and navigating supertankers. Sophisticated simulators reproduce the conditions of the major world waterways including detailed graphic presentations.
- b. Operators of nuclear and other energy plants.
- c. Technicians in the operation of communication satellites.
- d. Space shuttle crews.
- e. Process operators in chemical plants and refineries.
- f. Military maintenance personnel.(32)

Until recently it was very costly to produce simulators that would function for anything but the simplest situations. However, with the advent of microchips and video disk, the cost of simulators has come down. Moreover, manufacturers have developed software packages that can be used for a number of different simulations. With their greater availability, the understanding of how to design and use them goes up, so that they are likely to become increasingly important in training.

We have also been told that in various situations the line between simulation and reality is getting hard to draw. The trainee starts out doing simulated exercises and gradually the exercises become "real", as for example, when in CAD/CAM the device on which the student is learning by simulating designs is hooked up to the production machine and an actual product is produced from the design.

E. EMULATORS.

Emulators, or what Orlansky and String call three-dimensional simulators, are the next step closer to reality from simulators. Emulators look and perform very much like the actual equipment except that they are made rugged to withstand student abuse and with special safety features to prevent exposing students to dangers. They may not contain all of the components of the actual equipment and may operate more slowly or, for example, with lower resolution and less memory. The advantages of the emulator are similar to those of the simulator except that the experience of working with them is more realistic.

At the Milwaukee Area Technical College, Victor Langer uses them to teach CAD/CAM. The students are exposed to exactly the same problems they would encounter on the job and, except for the speed of response, they get the same results as though they were working on the real machine.

The field of computer graphics and animation is also now using low-cost emulators to prepare people for use of more powerful graphics design machines. These machines are introducing powerful new communication tools for all areas of training. Ours is a highly visually oriented society. The most powerful impact that television has had on education has not been as a result of its use in formal schooling, but has come from the thousand of hours of television watching that our children do even before they start school and during all their years of school. Many people learn more through graphics communication than through aural or print and some people — those whom we have labeled as "learning disabled" — may only be able to learn through visual imagery.

Up to now, producing visual images was costly and, relative to what is now possible, cumbersome. Today graphics systems can be purchased for under \$5000 that have the capability that only a few months ago would have cost \$50-100,000. And artists with the new machines are discovering expressing capabilities that were never possible before.

Examples from two extremes of the learning continuum are suggestive of what is becoming possible. In medicine a considerable portion of what a physician in training had to learn was how to "translate" the blips on a screen into an understanding of what was going on in the organism generating those blips. Today, with new imaging systems, the student can see arteries expand and contract under differing stimuli. These are not merely simulations of the "real" thing, but computer transformations of the data into pictures instead of blips or tables of numbers. The result is that the student — or the experienced physician learning a new procedure — can achieve understanding of processes and interactions much more directly than was ever possible before.

At the other extreme, Guy Nouri, president of Interactive Picture Systems in New York, has developed a frog dissection program for elementary school children. It permits even very young children who lack the motor skills to do a dissection to identify the parts of a frog on a computer screen and to do various "experiments" to discover how those parts function together.

Similar programs can be developed for every complex system and it is certain that creative designers will develop visual means to help people grasp even very abstract concepts. One of the most important areas for application of this technology will be in the area of basic skills. Adults — and children — who have been barred by their difficulties with print and abstract reasoning from acquiring the skills needed to solve problems and function effectively in a complex society may be helped by our ability to express ideas in visual imagery.

F. TELECOMMUNICATIONS.

Television is the most widely known and used form of telecommunications for instructional purposes but it is by no means the only nor, probably, the most important long run use. As we noted in the discussion of television above, one of the limitations of broadcast and most cable television is that it is one-way communication. To be most effective in education and training communication must be at least two-way — between teacher and student — and, preferably, "multi-way" to include communication among the students. In adult education particularly the opportunity for learners to express their thoughts to others and get feedback from them is an important part of the learning process.(33)

Increasingly now the telecommunications that is being used for education and training is more than one-way. The three primary forms are audio, video and computer.

Audio teleconferencing involves the use of the telephone to connect participants in two or more locations. Because almost everyone uses a telephone regularly and may even have participated in a conference call, it is often thought that audio is simple. However, as Bullen and Johansen point out, "audio systems are the most technically difficult of any even video."(34)

This is because people will accept fuzzy pictures on video, but if they cannot hear clearly communication fails. To achieve high quality audio requires sound-treated rooms, sensitive microphones, preferably voice actuated so only the speaker's microphone is "live" at any one time, good connecting switches or "bridges" and clear lines. Such facilities are now available from several commercial vendors and in at least one state system of education, Kansas.

The Kansas Board of Regents has for many years operated a statewide audio conferencing system over which courses are offered to students, primarily part-time adults, throughout the State. The courses run the full gamut of offerings including, heavily, courses for continuing education in the various professions. Students may participate either at conferencing centers located throughout the State or from their own phones.

The primary advantage of the system is that it enables people to take courses who would not otherwise be able to do so or only if the University went to the considerable expense of sending instructors to off-campus locations. Studies of the program over the years have indicated that students in the telecourses do as well as on-campus students.

A business application of audio conferencing is the use of a system called Teleforum for professional development and management training in office automation. The sessions were held five times during the year and each of the thirty participating organizations had between five and twenty-five people present. At an average of ten people per session, the cost was less than \$20.00 per training hour, which, according to N. Dean Meyer represented "a dramatic price breakthrough for high-level professional development." (35)

The drawback to audio conferencing in addition to the facility/equipment problem, is that most people find it hard to participate actively in such settings because the usual visual cues are not present to indicate who is to speak next and the speakers have no way of telling if anyone is paying attention. It is not, therefore, a medium that is likely to be used widely for worker education and training. Also, of course, such training usually requires some visual material and, often, the need for demonstrations or hands-on experiences which are not possible in a pure audio system.

Both video and audio conferencing require that all participants be on-line simultaneously, a factor that limits their utility in instructional situations where it is difficult to arrange for instructors and students to be at their several locations regularly at the times instruction is scheduled. This difficulty is eliminated by the third and newest form of teleconferencing, computer conferencing.

This medium results from the linkage of computers and telecommunications systems. A single computer, which may be anything from a micro to a mainframe, serves as "host". To participate in a computer conferencing system, one needs only a computer, terminal or word-processor with communications capability, a modem — a device to connect the computer to the telephone system, and an account on a conferencing system. From most places in the U.S., a local phone call will connect one with the system. Once connected, one can read and send messages. The messages are stored by the host computer and delivered to the intended recipients whenever they sign-on and ask to see their messages. This feature means that people communicating with one another need not be on the system simultaneously. Moreover, messages may be sent not only to one or more individuals, but they may also be sent to "topics" or "conferences". It is this last feature that is the basis for the instructional use of this medium.

In a course offered via computer conferencing, the instructor may enter lectures as "messages" and/or make assignments in books or materials distributed by mail. (When the mails are used, computer courses become a powerful new tool for

correspondence education.) Students may "attend" the lectures at any time from any place where they have access to the necessary equipment. Increasingly, that place is likely to be their own homes. The students may leave their own messages. These may be questions for the instructor or comments on his presentation or on comments made by other students. Because of the ease with which students can react to others in the course, there is often as much interchange among the students as there is between the students and the instructors.

Because the messages are stored in the computer, students can enter courses at any time and, if they have to miss portions for any reason, everything is there waiting for them whenever they sign in. Since access can be had from anywhere, students who travel can, with portable computers, keep fully up with the rest of the class.

At any time that a subject comes up that is of interest to only some members of the class, they may set up a "branch" conference for discussion of that topic — with or without the participation of the instructor. Instructors, too, can use the branching feature to structure the course.

Participants may also send private messages to one another or to sub-groups within the larger group. Instructors can use this facility to provide individual guidance to class members who may be having difficulties with particular aspects of the course content or with the conferencing process.

If students are required to prepare written work of any kind, it can be delivered "on-line," and the instructor can return comments in the same way. Course work may also require accessing on-line data bases and the results of that effort can be shared either with the whole class or just with the instructor.

Using a polling facility that is available in most conferencing systems, instructors can use feedback devices of all kinds from short quizzes to reactionnaires to elicit opinions on issues raised in the course. These latter often provide rich material for further discussion since, after "voting," participants can see the results of the voting, although, not how any individual voted.

Computer conferencing has been used for several years by the Western Behavioral Sciences Institute for high-level management seminars. The advantage in this application, besides eliminating the need to have participants take time away from their jobs, is that they can relate what they are learning in the seminar directly to their jobs. Many of the "exercises" involve discussions of real problems in "real" time.

The New Jersey Institute of Technology has been giving a number of its continuing education courses, such as ones in management, computing and communications via its computer conferencing system called EIES (Electronic Information Exchange System). This fall the New York Institute of Technology will be offering degree credit courses over its conferencing system called "Participate" which was developed by Participation Systems, Inc.

Another variation on the use of computer communications for instruction is the concept being developed by TeleLearning Systems Inc. in San Francisco. One of the limitations on the extensive use of computer conferencing of the kind described above is the cost of time for communications. Telelearning has addressed that problem by providing a communications package which automatically connects the student to the system and sends and receives messages very quickly. All the student's writing and reading is done off-line.

TeleLearning is aiming its offerings at adults who wish to complete their education or up-grade their skills in specialized areas. Its current catalogue includes non-credit personal improvement courses, some degree-credit courses, and courses to help prepare people for the College Level Examination Program (CLEP) from the College Board. Each instructional package includes textbooks, study guides, computer disks with lessons and exercises, and the communications package. Students respond to the assignments by writing their responses on a disk and then signaling the system to send them. Instructors generally respond within 48 hours so that the student gets a rapid response to his "homework". There are also opportunities to engage in discussion with instructors.

According to Telelearning staff member Laura Malone, it is hoped that this rapid response time and opportunity for some interaction will mean that the attrition from TeleLearning courses will be significantly less than from traditional correspondence courses.

TeleLearning courses now run on Commodore, Apple and IBM computers. The communications package runs from \$49-\$199 depending on machine, and the course fees range from \$45 for some non-credit courses to \$250 for some three-credit offerings.

David Hughes, a private teleconferencing consultant in Colorado Springs, has been conducting his own writing courses on his own conferencing system which he operates on a microcomputer in his home. His example shows the potential for private entrepreneurs to by-pass institutional structures to offer learning opportunities to those who want them. Of course, situations of this kind raise large issues of control and

"consumer protection" just as do the offerings of the institutions mentioned above, since their courses can be "delivered" in any state regardless of whether or not that state's educational authority has approved them. But each new technology challenges existing arrangements and, in time, accommodations between the new and the old are usually made.

Just how valuable a tool for adult education and training computer conferencing becomes will depend in part on the spread of computers with communications capability and in part on the quality of the offerings provided. For some adult learners, particularly those who are severely handicapped or have jobs that make it impossible to meet any regularly scheduled classes, it will be the only way that they can participate in organized learning opportunities.

G. JOB AIDS.

Embedded training, which was discussed above, is a special case of a more generic approach to helping workers perform effectively on the job. That approach is called a "job aid." A job aid is a procedure for helping a person remember or learn how to do a task at the time when that task is to be performed. It is, according to Donald Bullock, "anything that is added to performance to enhance or improve it." (36)

Bullock distinguishes aids from prior instruction in terms of the extent to which performance depends upon guidance provided by the aid and upon recall from prior instruction. He says:

Job performance aids reduce the need for reliance on recalled skills/knowledge, even though instruction in the use of job performance aids may be (and usually is) necessary.

Such aids, he claims, are more cost-effective than instruction, more timely in that they can be developed faster than an instructional program, more easily updated than instruction, and more relevant to a specific job. They also can help smooth the transition from instruction to job performance.

That is exactly how job aids are used in the blood analyser training system developed by DuPont Biomedical Products, according to Thomas Jenkins, Manager of Learning Systems. A self-instructional learning system was developed to replace the lecture-style training program that had previously been used to train operators from around the world in the use of this complex piece of equipment.

Formerly trainees listened to lectures, saw demonstrations and had limited opportunities to practice on the

actual equipment. The new training involves the use of text, audio and video tapes, CAI and instruction embedded in the equipment. The system cost \$900,000 to develop but because it cut training time from five days to three and permitted the training to be done with half the amount of staff on twice as many machines for half the cost of the previous training, the investment was paid off in 18 months.

As important as were all of those savings, back home job performance improved. Jenkins attributed this to the fact that the students learned to use the machines on their own (with the help, of course, of what might well be called "instructional job aids") and had access to most of those aids when using the machines. This was a case where the job aid did what Bullock suggested: smoothed the transition from instruction to job performance.

Many of the most effective job aids do not require the use of technological devices at all. Well-designed print or graphic materials are often all that is required. These may not differ much from old-fashioned maintenance manuals except in the attention that is given to their design. Indeed, many of the trainers whom we interviewed argued that the determination of when and how to use job aids is itself a "technology" and should be noted in any overview of how technology is helping with the training task.

The Little Company of Mary Hospital in Evergreen, IL, with its more than 1800 employees serving some 18,000 patients in a year at a total budget of \$72 million, is a typical metropolitan area hospital. According to Gregory Finnegan, education director at the hospital, they make extensive use of job aids in many of departments. For example, job aids are used to reduce the training required for maintenance personnel. Every valve, switch or other device that might cause trouble has a job aid attached to it which describes what is to be done in case of trouble. This procedure made it unnecessary to have a skilled building engineer on-site at all times and enabled the regular maintenance crew to handle most problems — indeed handle them before they became emergencies.

Among the departments using job aids and the problems addressed by them were these:

- * Blood bank blood warmer operating guide: Nurses did not operate equipment often enough to become proficient.

- * Laboratory sweat test procedure guide: Off shifts with fewer chances to do the procedure need reminder.

- * Nursing arterial flush procedure guide: Staff needs to learn to use new equipment.

* Nursing bristoject procedure guide: Staff needs to know procedures to conform to new regulations'.

* Plant operations air conditioner procedure guide: Infrequent use creates a training problem.

* Plant operations water in furl tank troubleshooting manual: Occurs rarely and is emergency.

* Radiology ultrasound procedure guide: Made possible operation by others than chief technician.

These were some of the results of using the aids:

* Medical services cart washer procedure guide: Before took two hours to train staff to use; with aid 30 minutes'.

* Medical services washer/sterilizer procedure guide: Before 8 hours to train; with aid 30 minutes'.

* Blood bank blood warmer guide: Before Blood Bank received two calls per week to show nurses how to operate; with aid, no calls.

* Intensive care unit arterial flush guide: Before supervision required for 30 minutes per use 10 times a week; after aid no supervision required.(37)

Many trainers with whom we talked said that an increasingly frequent response to a situation that might in the past have led to a training event is development of a job aid. Job aids seem to be prescribed whenever the skill or knowledge required is so infrequently used that, even if people were trained, much of what they are required to do has been forgotten when the time came to use it'.

They are also used on jobs that require workers to remember lots of detailed steps and do them in proper sequence'. Such jobs put a heavy burden on the memories of the workers. In order to insure that procedures will be followed, in the past it has been necessary to provide sufficient opportunity to practice the procedures to be sure they would be performed with minimal error'. With job aids, the memory burden can be reduced. In the case of telephone service representatives, training time was cut by one-third and errors were reduced through the use of job aids.

H. OFF-THE-SHELF PROGRAMS.

Over one hundred vendors advertise programs using almost all of the above media, singly or in combination, for a wide range of training needs'. Only very rarely did any

interviewee mention the use of such packages, except for users of the PLATO, CCC and WICAT materials. Morohl did say that NCR used a McGraw-Hill course in basic electronics that involved self-paced workbooks, with some audio and video tapes.

We did hear assertions that were few or no good programs (Bullen, Katz, Gustifson, Buffer, Harmon, Harless, Hoelzl) and assertions that good training has to be situation-specific and cannot be met with off-the shelf programs no matter how good. We have no way of judging these claims and found no evidence of any systematic evaluation of the claims for effectiveness of the packages, except for the journal, HRD Review, which is published specifically to provide trainers with evaluations of training materials. In the year and a half since it began publishing, the Review has evaluated more than 125 training programs, of which nine were classified "multi-media" and twelve were "video-based." While reviewers, who are volunteers from the training field, are encouraged to try the materials in actual work situations, there is no way to assure that this is done or to impose any sort of common criteria on the reviewers. The reviews are limited to 500 words. (38)

According to George Khoury, editor and publisher of the Review, the response of trainers to the publication has been very strong. "They welcome guidance from an independent source," he says, "to help them sort out the claims of the vendors." His impression from talking to subscribers and vendors is that the use of packaged training programs is growing. Videotape is the most widely used of the media, with very little yet appearing for computers.

We did search to see if there were any off-the-shelf programs for adult basic skills other than the PLATO and CCC materials. There is a television series designed to prepared adults to take the GED examination. Although developed many years ago by the Appalachian Regional Laboratory, it is still used by some adult education programs over cable systems. Users say that it does help adults who stay with the program but there have been no recent assessments of it.

The closest to a computer-based program that we could find in this category is the GED-100 Program developed over the past two years by Educational Software and Marketing Co. (ESM) of Springfield, IL. That program, however, does not provide instruction but only uses a microcomputer for diagnosis, testing and prescription. When students' deficiencies are identified they are referred to class and texts for remediation.

According to ESM president, William Mayes, no systematic studies of the effectiveness of the program have been done. In two years it has only been bought, at a cost of \$975, by 40

institutions. It has, however, just been acquired by a publisher of adult basic education materials, Steck-Vaughn. Mayes said that he has been on the look-out for instructional programs that would complement the GED-100 but has found nothing.

One other packaged program that involves considerable use of media is the Adkins Life Skills (ALS) program developed by Winthrop Adkins at Teachers College in New York City. This program has been extensively used with displaced workers. ALS focuses on the problems individuals face when they are out of work and need to find a job. It is claimed that it works both with new entrants to the labor market, such as youths and displaced homemakers, and with previously employed people who may never before have had to look for a job.

The core of the program is a set of video tapes that present in dramatic form the kinds of problems that people encounter in the process of seeking a job. The tapes are designed to stimulate discussion in small groups with a trained leader who helps the participants work out solutions to the problems that they have and that the tapes help them to articulate and externalize.

Adkins chose video tape as the medium for instruction because he had become convinced as a result of years of work as a trainer of adult counselors that there was no way that enough properly trained people could be prepared to meet the needs of all the adults who need some form of counseling assistance. "I felt strongly, however," he said, "that people could only be helped deal with situations in which they were really hurting in interaction with other people." He therefore decided to use technology to capture the expertise of the trained counselor in a form that could be used by less trained individuals. "What we produced," Adkins claims, "is a set of tapes that skillfully help people identify the sources of their problems and a set of print materials that help facilitators and learners in a group setting work through to solutions."

While ALS has been used by over 300 programs and there are strong claims for its effectiveness by those who use it, there has been no systematic study to determine how well it works in comparison with other methods.

Because the numbers and costs of off-the-shelf programs involving the use of technology is certain to increase, an important study would be to examine the basis for the claims of the vendors and to conduct an independent evaluation of the more promising programs. Such a study should assess not only the individual offerings, but seek to identify the characteristics of programs and the uses of media that are effective with differing kinds of learners in differing situations and learning settings. The HRD Review has made a start in this direction, but a more extensive effort is needed than can be mounted by volunteer reviewers for a publication with limited resources.

III. FUTURE HARDWARE/SOFTWARE SYSTEMS.

There are many hardware and software developments which are or are expected to be available in the near future that will greatly effect the education and training of adult workers. Almost all of these use hardware, software and concepts that already exist but are not yet used for instructional purposes.

Joseph Lipson of WICAT Systems has provided the following list of future educational technology in the workplace that is feasible in the next decade with current or projected hardware and software capabilities: (1)

- * Truly portable learning stations with a flat, high resolution screen that could be used at the worksite to support "embedded training which has the potential to revolutionize learning in the workplace."
- * Low-cost, high speed, letter quality, small laser printers. Would facilitate workplace learning by providing letter quality hardcopy printout at the worksite.
- * Low-cost, easily usable optical character readers which would permit any text document to be read into computer memory without having to be re-typed. Would greatly increase access to information resources for training purposes, particularly in rapidly developing fields like engineering and computer science.
- * Condensed and synthesized speech to accompany still frames on video disk. Would increase the information content of the instructional program since it often takes more words to explain a picture than can be put on the present disk sound track.
- * Speech recognition. Would have broad application in training from reducing the time and effort needed to learn to operate complex machines or software systems, to enabling anyone to generate text without having to use a keyboard. In combination with graphics systems, would enable anyone, but particularly non-literates, to develop and express ideas.
- * Computer written programs. Would reduce the training needed to write programs and increase the availability of computer-based training programs tailored to specific situations or learner needs.
- * An authoring technology (equipment and theory of authoring) for interactive video disk production. Would greatly increase the efficiency of course development.

To this list Verl Dennis, of Arthur Andersen Co., adds wider use of voice synthesis. When anything appearing in words on a screen can be sounded out, non-literates will be able to use computer-based devices and any trainee will be able receive instructions without having to take eyes away from work.

The Department of Defense already has a device that uses the spoken word for communication with the user. Called "Personal Electronic Aids for Maintenance (PEAMS):

It offers immediate access to technical information for experienced and inexperienced users. The inexperienced technician can follow the step-by-step procedures...Its objective is to solve, through automation, the problems that have prevented wider use of job/skill performance aids.... Because the information is delivered and reviewed via spoken word, the PEAMS system avoids some training and job performance problems related to low literacy levels.

PEAMS may also have the kind of "authoring technology" that Lipson is looking for since it:

offers a complete production environment, including a fully integrated, high-performance work station for the production of text and graphics; structured authoring tools such as front-end analysis, troubleshooting procedure development, nomenclature control and procedural text development without use of a keyboard; graphic development tools tailored to the technical illustrator; and project management tools such as schedule/task control, personnel management, configuration management and on-line communications. The author can incorporate relevant technical instructions, background policy information and systems specs into one easily adapted and updated delivery system.(2)

While PEAMS combines video disk and computer, some project that instructional technology will only become effective when computers can handle text, data, graphics, still and motion pictures, and sound all in digital form and can use the telecommunications system to share that information among computers. The technology to achieve that degree of integration is presumably very close to becoming commercially available.

Louis Robinson of IBM supports Lipson's view that simpler user interfaces with computers are coming:

Machines must become much less complicated to use. I believe that is happening....Knowledge based systems or expert systems are interactive and are built around data structures which can represent all the relevant problem domain facts and their interrelationships. Its interactive dialogue acts as an

intelligent consultative system to the user....Information processing has certain inherent complexities... Until now, a great portion of that complexity was handled by the user. But (soon it will be) absorbed by the computing system itself.(5)

One variation of the expert system approach was under development by the military called "Intelligent Computer-Assisted Instruction" (ICAI). According to Orlansky and String:

In ICAI subject matter knowledge is stored in the computer, but not in the form of previously defined lessons. Instead, the computer models each student and selects stored subject matter material to construct instructional interactions for individual students. These interactions can be very flexible, and hold some promise for "human like" tutoring of students.(4)

"Expert systems" are likely to have two significant impacts on training:

1. They will, on the one hand, reduce the type and amount of training required for knowledge-based occupations such as the professions.

2. They will, on the other hand, make it possible to embed in machines the growing understanding of how to motivate and assist people to learn. In Christopher Evan's dramatic language:

The computers and the programs they offer will be carefully prepared to make sure that the user, at whatever intellectual or cultural level, will be highly motivated to use them....The world is about to move on from the era where knowledge comes locked up in devices known as books....In the era it is about to enter, the books will come down from their shelves, unlock and release their contents, and cajole, even beseech, their owners to make use of them.(5)

An adult education future much less dominated by technological devices was projected by a group of educators convened by the National Home Study Council in 1981 to examine the future of distance education. After reviewing dozens of futures projections, this group of 25 made a number of predictions which included the following:

*Printed correspondence course text materials will be the key component of the distance education package of 2001. (A striking contrast with the views of Evans, Lipson, and many others who see technological delivery predominating by that time.)

* Home study educators will "rediscover" the media of radio and telephone conference calls as means for direct interaction with students.

* Adult students will want to interact with advisors, counselors or instructors on a "real time" basis.

*Communications will be the vital link between the student and the instructor.(6)

To be sure, distance education is only a part of adult education and training, and the Home Study Council may have a special interest in having the results come out as they did, but, given the history of the spread of innovations in education, this group may turn out to be closer to the mark than some of those expecting more revolutionary changes. We will discuss the barriers to rapid adoption of innovations in education in Chapter XI.

IV. SETTINGS IN WHICH TRAINING OCCURS.

Our investigation by no means constitutes a systematic attempt to identify the numbers of organizations that are using technology in the education and training of adult workers. Our impression is that they now must number in the hundreds, including most community colleges and public and private vocational-technical schools, and such giants as the U.S. Department of Defense, General Motors, IBM and AT&T.

One of the unions whose members are most involved with technology in their day-to-day work is the Communications Workers of America (CWA). It has a major program for continuing workplace education. According to Glen Watts, president of CWA, "a key ingredient of this program will be the CWA's support of community colleges and vocational technical schools in their development of courses, some of which are directly related to the development of information industry skills." (1)

The comments of Dale Parnell on the respective roles of business, industry and the colleges is of special note because of his special perspective as president of the American Association of Community and Junior Colleges (AACJC). In a recent Association newsletter he wrote:

The conundrum of the century is the degree to which schools, colleges, and universities are buying technical training programs from business and industry....Have business and industry taken over the training market? Where do community, technical, and junior colleges come down in all of this?...It will be most difficult for our colleges to keep up with the specific requirements of companies operating at the cutting edge of new technologies. However, as a given technology develops, the required competencies become transferable among many different employers. It is at this point we see the training function increasingly being transferred to our colleges. This transfer process requires the formation of new partnerships and a continuing dialogue between colleges and employers. (2)

We found a number of institutions in which that transfer is already taking place. The institutions are working closely with individual industries or consortia to design curricula and put in place opportunities for the kinds of hands-on training that is essential in most high-tech fields. Indeed, a characteristic of each of the examples that follow is that the technology used to deliver instruction is in most cases also the technology that is the object of instruction, e.g., students use computers to learn about computers. Is such use of technology only an up-dated version of traditional vocational training in

which hands-on experience played a key role, or is the technology also playing a role in the delivery of the instruction? The impression that we have gained is that in most instances training designs are embedded in the devices so that the student's use of the tools is being in part guided by the tool.

An example is what has happened at the Milwaukee Area Technical College (MATC) which faced the problem of providing high-cost high-tech CAD/CAM education for industries in the area. At the core of the problem was the high cost of industrial CAD/CAM stations which at \$150,000 per design station was more than the College could afford. With help from the industries involved in the form of donated equipment and funds and a grant from the National Science Foundation, MATC "implemented a high-cost industrial CAD/CAM technology training system achieving a ratio of 35 students to one design station available 80 hours a week." These coupled with low-cost microcomputer CAD emulators and a curriculum developed in close collaboration with an industry advisory committee, has made it possible for the College to help address the need of industry for "some 100,000 operators in the four years ahead."(3)

Another example of an institution that closely integrates its instructional delivery system with the technology in which it specializes is Capitol Tech in Laurel, MD. The students learn on the technological devices that they are learning about such as computers and state-of-the-art telecommunications equipment.

Another partnership between business and industry has been formed by the Telecommunications Training Consortium with headquarters at Skyline College in San Bruno, CA. The basic purpose of the consortium is to create a nationwide educational program for the telecommunications industry based primarily in the "nation's community colleges." One objective is "to offer all instruction in a computer-assisted, video-interactive format that is easily transported."(4)

Another institution that has entered actively into the dialogue with an industry with which it is closely associated is the Fashion Institute of Technology in New York City (FIT) which recently celebrated its 40th anniversary. In a publication setting forth its mission for the future, Marvin Feldman, FIT president, succinctly positioned his institution this way:

The line of demarcation between the fashion industry and The Fashion Institute of Technology is invisible. FIT is a central part of the fashion industry as well as a center of learning for the industry.(5)

Elaborating further on this theme in an address to the New York Board of Trade, Feldman said:

If technology is blurring the traditional distinctions in manufacturing and distribution, it is practically eradicating the distinction between industry and the educational institutions that train its people. There is no more dramatic phenomenon in the 1980's than the explosion of the collaborative efforts between industry and education as they try to cope with the torrent of change the electronic revolution has produced.(6)

That revolution, according to Feldman, is the only thing that will save the textile industry from near extinction in this country. With the help of new computer-based machines, it is "becoming almost worthwhile to produce textiles again in this country." The reason is that the textile and fashion industry, like to many others, is being transformed by computer-based processes and machines that will soon displace most of the crafts if not the craftsmen in the traditional garment trades.

For example, today a designer draws a design on paper which is then turned into patterns by a pattern maker; those patterns are laid out on cloth and cut by skilled fabric cutters — three separate skills all requiring long training and manual dexterity. In the new system, the designer will do his/her work at a computer graphics terminal which will allow for greatly enhanced opportunities to experiment with alternative designs. When the designer is satisfied with a design, the machine will translate the design into directions for a cutting machine. That machine will not only lay out the patterns on the cloth so as to minimize waste to a degree that only the most exceptional older worker could attain; it will also cut hundreds of pieces of cloth simultaneously to tolerances unattainable by even the most skilled craftsman.

Thus old skills will be replaced by new and many fewer workers will be needed to do the new jobs, although, Feldman suggested, new jobs will be created in other sectors of the industry such as marketing and direct customer services. Just as important, new levels of creativity and of quality control will also be possible.

All of these changes are just coming into place. One of the roles the Institute is playing is to help introduce these changes to the industry. It conducts regular seminars for industry and union leaders on the new systems and machines and it is training the workers who will introduce and use the new systems and machines.

Here Feldman pointed out a dilemma that institutions like his face in trying to provide the training for advanced technologies. The industry is still dominated by large numbers of small firms that are using older technologies. Since they are

the primary sources of jobs for graduates of FIT, students have to be trained in the traditional technologies. But to enable them to help change the industry, they have to be trained in the new technologies as well. To do both jobs at the same time is expensive.

The problem is compounded by the enrollment-based funding formulas used by most public authorities. Those formulas do not recognize the high per student costs engendered both by the need for redundant training and by the high costs of the new technologies.

In spite of these limitations, FIT is making heavy use of technology-based instruction to prepare students for the "new" textile industry. Much of that instruction is done using the technology itself, as when student designers are taught design on computer graphics machines — a practice similar to that which we found in other industries using high technology.

Cuyahoga Community College (CCC) in Cleveland, Ohio, is another example of a two-year institution using a wide variety of new technology devices to educate students, most of whom are adults (average student body age is 29). CCC uses the PLATO system for instruction. In addition, CCC produces its own telecourses which are sent to eight cable companies in the Cleveland area via WVIZ-TV's ITFS system.

The school is now able to offer advanced courses to its three separate campuses through a new two-way microwave link. The system is designed for two-way audio and video transmission, so that the instructor can view students at distant locations through special monitors as well as hear them through microphones.

From 1972 to 1976 PLATO was evaluated at five community colleges in the Chicago area. One hundred sixty two classes in accounting, biology, chemistry, English, and mathematics were evaluated. Average student use of PLATO varied from a few minutes to more than 20 hours. The most significant finding was that student achievement with PLATO was about the same as for regular classroom instruction. Because of the way PLATO was used to supplement classroom instruction, comparisons of time to achieve objectives was not relevant. (For further discussion of this study, see Chapter V.) (7)

A similar program, TICCIT (Time-shared, Interactive, Computer-Controlled, Information Television) was evaluated in 1975-76 at Phoenix College, Arizona, and the Alexandria campus of the Northern Virginia Community College. Over 2600 students were enrolled in the TICCIT courses and they were compared with about 3000 in corresponding lecture courses. The TICCIT students had

slightly higher test scores and completed the courses at a higher rate than the lecture students. However, other data indicated that the TICCIT students were more highly qualified than the other students, which could account for most of the differences. (See Chapter V for further discussion.)(8)

It is unlikely that many of the students involved in those programs were adults so that even if the results were more meaningful, we could still not be sure that they would apply to the populations of interest here. We were not able to follow-up to see if these systems are still in use and whether adults are now involved.

A 1983 comprehensive study of telecommunication in educational institutions by Raymond Lewis included 14 two-year colleges which were using a variety of devices to serve their students, many of whom, being off-campus, were adults.(9)

Two of the institutions had programs especially for workers — the College of San Mateo and Rio Salado Community College. San Mateo operates an Electronics Worksite Training Project funded by the California Worksite Employment and Training Act. The project provides entry-level training (not using technologies) and up-grade training for workers already in entry-level or other limited-mobility jobs in the electronics industry. The project also enrolls 170 students in a program it operates in 22 learning stations located in 12 different companies in the San Francisco area. It is one of the few microcomputer/videotape interface instructional programs in the United States, offering employees a self-paced, open-entry/open-exit curriculum at a worksite.(10)

Rio Salado, a noncampus college of the Maricopa County Community College District, uses television, radio, cassettes and other devices to reach its 1,000 students, 67% of whom are employed and 73% are women. Programs at the school also serve students at a women's prison.

The majority of the courses are in credit bearing introductory core and elective liberal arts subjects. In addition, some courses in occupational subjects and in areas of interest to adults in the community, such as in small business management and nutrition, are offered, but not for credit. The occupational courses are part of a program called Occupational Update for employed people, not for persons seeking to qualify for employment.(11)

Lewis' findings regarding the other two-year institutions are summarized in Table II.

Except for the use of television, four-year colleges and universities seem to be less involved in the use of technology

Table II.
INSTRUCTIONAL TECHNOLOGY AT TWO-YEAR COLLEGES.

COLLEGES	Broadcast TV	ITFS	Microwave-- point to point	Cable TV-- one way	Cable TV-- interactive	Slow Scan TV	Video Teleconferencing	Radio	Telephone	Audio Teleconferencing	Telephone Access	Audiotape Videotape	Audiotape	CAI	CMI	Computer-- videotape	Computer-- cable
Central Piedmont CC	•			•				•	•		•	•	•				
Chicago City-wide CC	•							•	•			•	•				
Coastline CC	•							•	•			•	•		•		
College of San Mateo									•			•		•		•	
Columbus Tech. Inst.					•				•			•					•
Dallas Cnty C.C. Dist.	•			•				•	•			•	•				
Kirkwood CC		•	•	•			•	•	•			•	•				
Los Angeles CC Dist.	•								•			•					
Miami-Dade CC	•	•		•				•	•			•	•		•		
Milwaukee Area Tech.	•			•				•	•			•	•				
Northern Virginia CC	•							•	•			•	•				
Queensborough CC									•	•				•			
Rio Salado CC	•			•		•		•	•	•		•	•		•		
Tacoma CC				•				•	•		•	•	•				

Source: Raymond J. Lewis, Meeting Learners' Needs Through Telecommunications: A Directory and Guide to Programs (Washington, DC: American Association for Higher Education, 1983).

for the training of adults (or youth, for that matter). Writing less than two years ago, Fred Davison, president of the University of Georgia, observed that "recent breakthroughs in semiconductor technology are beginning to provide educational institutions with technology at the price and the capabilities needed for major changes." And commenting on his own institution he said, "In the past, the University has not engaged extensively in computer-based instruction. This year (1982), however, an aggressive new program will lead to the installation of up to 100 CBI stations." (12)

The reason that Davison (and others) believe that not much is going on in the colleges and universities may be more the of writing about developments than because such developments are not occurring. As Marc Tucker writes in his collection of descriptions of computer activities on campuses:

Campus leaders most directly involved are much too busy...to write reflective articles for scholarly journals describing the fast moving events in which they are key participants. (13)

Tucker then describes four applications of computers to instruction:

- * At the University of Maryland, where computer simulations on Atari 800's are being used to teach beginning optics.

- * At Colorado State University, where a course in macroeconomics will be taught using an off-the-shelf software spreadsheet program, Visicalc, running on Commodore computers.

- * At the University of Illinois, where an approach called "hypertext" is being used to change the way pathology is being taught. (Hypertext is another future system that we might have discussed earlier.)

- * At Milwaukee Area Technical College. (See discussion above.

Tucker concludes his survey by noting that:

Computers and telecommunications systems are on their way to radically transforming the way work gets done in our society, and they (the universities) are prepared to make commensurately radical changes to be sure that...they will have...an approach to teaching that enables both student and teacher to make the most of the time they have together. (14)

However, in an even more recent commentary on computers in higher education, Alfred Lee from the New Jersey Institute of Technology writes:

With some exceptions, higher education has waited to see whether personal computing is really more than an infatuation with an obedient tube. Although it helps with office work, why should it belong in the general curriculum? To much of the national professoriate, computing is still something the computer science department does." (15)

As a result of the current FIPSE-funded survey by the Educational Technologies Database Project at Harvard, we will soon know much more about "the uses of microcomputers in educational settings nationwide." A questionnaire was sent this summer to schools, higher education institutions and "alternative educational settings." Since the instrument addressed to this latter group is the only one which explicitly asks if the programs serve adults, it is provided here to show the kinds of information being sought.

In light of our discussion below on the limited information available on effectiveness, it is interesting to note that the survey only asks for effectiveness information in a very indirect way and is hardly likely to turn up any useful data on effectiveness unless some "piece of software or software package" turns up in a large number of the responses, a result, we would predict, that is very unlikely given the varying objectives and standards of judgement at differing institutions.

Information about projects using technology in the instruction of adults is also available in the catalog of computer projects published by the Department of Education. The catalog lists all projects funded by any DOE agency in 1983. (16)

Of the 275 projects listed, 45 or 16% involved adults. These 45 programs accounted for \$4.8 million or 6% of the total of \$77 million of the awards. In view of what has been said elsewhere in this report about the high cost of developing effective computer-based instructional programs, the most significant feature of the summary is the range in size of the awards from one under \$2,000 for one year to one over \$800,000 for three years. Almost half (19) of the projects were under \$25,000 per year and all but 10 were under \$100,000. Even with the local contributions that were probably necessary in almost all cases, these are not, for the most part, at the scale that would produce results that are likely to be usable elsewhere. Nevertheless, most of the abstracts mention some form of usable product and dissemination activity — even those where the funding is less than \$5,000.

Of the 14 projects categorized in the catalog as "Research and Evaluation," only one grant, to the Shenandoah, PA, school district, provided for a comparison of adults receiving traditional instruction and those receiving CAI. That grant was

Harvard University Educational Technologies Database Project

MICROCOMPUTERS IN ALTERNATIVE EDUCATIONAL SETTINGS

PART A: Uses of microcomputers:

1. Are microcomputers in your facility used primarily _____ for instruction, _____ for resource, _____ for informal access? And is the instruction carried out primarily by _____ staff, _____ certified teachers, _____ volunteers, _____ peer teachers, or _____ self?
2. What is the age range of your participants? (Check all that apply)
 Preschool _____ Elementary school _____ Secondary school _____
 College _____ Graduate school _____ Adult _____
3. What brands and how many microcomputers do you use?
 AppleII, IIE _____ Atari _____ Commodore _____ DEC _____ IBM _____
 MAC _____ Radio Shack _____ Other (please list) _____
4. Approximately how much time does each participant spend using a computer per week?
5. What types of software are participants using in your program? (Check all that apply)
 _____ Word processing _____ Database systems _____ Spreadsheets _____ Communications _____
 _____ Software for specific subject areas (e.g., math, history, economics, etc.) _____
 _____ Graphics _____ Programming languages (specify) _____
6. Is there any particular piece of software or software package that you have found to be especially effective? Have you developed software for this use yourself? Please name and describe briefly.
7. What other materials are used?
8. What are the main objectives you hope to achieve through the use of computers in your course or program? What makes your use of technology particularly interesting or successful?
9. Please include a brief written description of how microcomputers are used in your facility. Include here information about use in labs, workshops, networking of micros, or networking of micros to larger systems as well as information about the substance and variety of materials available. If you need more space attach another page, but please do not write more than 200 words.

for only \$11,500. For that amount, no findings of any broad significance could have resulted.

Three others were concerned with software evaluation and the rest are concerned with developing guidelines or information resources for educators who want to use computers for instruction of adults.

The Department of Education, of course, is not the only Federal agency that sponsors education and training programs that involve adults. In 1976, we identified over 270 Federal programs providing education and training funding and programs for adults, dispersed across 11 different departments and numerous agencies and commissions.(17) The number of current programs is surely reduced, due to substantial budget cutbacks and, of course, only a portion of these would use the new technologies as part of their efforts.

In addition, to the Departments of Education and Defense, the Agriculture Department uses computers and other new technologies to train adults through the Extension Service. Health and Human Services sponsors the Centers for Disease Control which uses various training technologies in its programs. The Department of Labor is currently sponsoring research on the educational and employment implications of technological change in the auto industry (including robots). These are just a few examples of the scope of Federal activity.

While we did not study this specifically, our impression is that, beyond Orlansky's military studies, little evaluative research has been done on Federally-supported efforts in this area.

Earlier in this section we discussed the role of universities as users of technology in their own instruction. Another of their roles is to prepare people to design and use technology in instruction. Many people with whom we spoke in industry were concerned at their failure in this role.

For example, Verl Dennis from Arthur Andersen & Company, said that they had sixty people doing training this past summer but only five of them had the ability to use the kind of training technology they require. "The universities," he said, "are not turning out people with this kind of skill."

It is often said that one of the reasons for the slow adoption of educational technologies in our educational system is that so few of our teachers or faculty have learned anything themselves using technology. This is just beginning to change and it may be that the next generation of teachers will be more attuned by their own learning experiences to the role that technology can play.

Of even greater concern from the perspective of engaging universities in collaborative arrangements with industry, many spoke of the strong barriers within institutions to the kind of interdepartmental collaboration that would be required to create a strong program in instructional design.

Although we made no attempt to identify institutions with significant programs in educational technology and have no way to judge those we did hear about, we did receive descriptions of rather comprehensive sounding programs from the following:

Florida State University in Tallahassee — doctoral programs in "instructional design and development" and "instructional theory and practice."

San Diego State University — Certificate and master's degree programs in "educational technology" with a speciality in "educational computing."

University of Delaware in Newark — master's program in "computer based education."

Each of these programs makes a point in their literature of stressing that their programs prepare people for careers in industry. Allison Rossett, Professor of Educational Technology at San Diego State, states that the emphasis there is on examining performance problems on the job and then creating instructional packages to solve the problems. "We attempt," he writes, "to pair design and hard technology (computers, video, interactive video) courses." As illustrative of the link with industry, the University is "currently offering a Certificate in Training System Design and Administration for AT&T course developers in New Jersey." (18)

V. EFFECTIVENESS STUDIES.

We found very few systematic studies comparing educational technologies with traditional instruction or with other technologies for instructing adults. One of the few studies we did find begins with an explanation of this situation:

Evaluation has come late to the field of adult education. Because many programs for adults are of short duration and the curriculum is often non-sequential, evaluation attempts frequently have consisted of participant assessment rather than measurements of learning change. In addition, most of the technical competence necessary for evaluation is housed in educational institutions oriented almost exclusively to elementary, secondary and college education.(1)

Andrew Molnar at the National Science Foundation is one of the best informed observers of learning research in the nation. He told us that "there is no evidence from research that media make a difference in learning."

Richard Clark of the University of Southern California agreed with Molnar and has argued publicly that no further comparative studies of the influence of media on learning be undertaken because:

Most current summaries and meta-analyses of media comparison studies clearly suggest that media do not influence learning under any conditions....Basically, the choice of vehicle might influence the cost or extent of distributing instruction, but only the content of the vehicle can influence achievement.(2)

Over and over when we asked interviewees if they had done systematic studies of the programs in which they were using technology for training, the answer was negative. The reason may be indicated by a recent comment on evaluating training programs:

When training produces immediate improvements in performance every time, and those increases are large enough to be seen despite the inherent variability of behavior in the natural environment, then these designs provide powerful and convincing demonstrations of training effects....Unreliable programs are not bottom-line contributors.(3)

In short, businesses look for obvious measures of difference, such as significant savings in learning time, in travel costs, or in improvements in on-the-job performance. If the effects are large enough to be easily perceived, controlled studies are not needed to find out if the results were valid or

reliable. It works or it doesn't seems to be the prevailing attitude. And, of course, businesses have found many devices that work, as we shall show shortly.

Even in educational institutions, where it might be thought that there would be more interest in research, the studies have been meagre, for the reasons given by the Shwalbs. Research on adult learners generally has not had high priority, and this includes research on the use of differing technologies for teaching adults. There has been such a backlog of research on adults that in a 1978 research agenda for adult education, an advisory panel convened by Kurland did not include any topics related to technology in its list of 30 priority issues.(4)

The most extensive studies have been done by the military, but even there the efforts have been limited, as we will show later in this chapter.

A look at the forty studies found by the Shwalbs illustrates the points we have made.

They looked for studies "comparing the effects of technology instruction with adults and conventional instruction." From data bases for the period 1960-1980 they culled only forty usable studies, providing 43 comparisons of interest to them. Before we look at the studies, it is important to take note of a comment from Mrs. Shwalb on one of the key criteria used in selecting studies:

We included as an "adult" any person who did not follow the typical sequencing of education, i.e., adults in ABE programs, military personnel, etc., and those in higher educational training programs, i.e., medical students and other graduate training. Hindsight suggests that this second group should be looked at separately from a-typical adult learners. (Correspondence.)

Were this second group omitted from the studies looked at, probably at least eleven would be dropped, leaving only twenty-nine in a twenty year period. Table III has been constructed from the information provided by the Shwalbs.

In the following discussion, the first number always will be based on the full set of studies, the second with the eleven omitted.

First there is the matter of the technologies studied. The largest category was programmed instruction (27/24) (See Chapter XII for discussion of programmed instruction); "visually based instruction" was next (13/7) (only three of these were identified as involving television (2) or videotape (1)); and only four (two) were concerned with computers. This distribution is not surprising for the period covered.

Table III.

SUMMARY OF FINDINGS FROM COMPARISON STUDIES OF MEDIA WITH ADULT LEARNERS

Media/ Study	Date	Doc. Type	Number of Subjects Exp./Cont.		Type of Learners	Findings
<u>Programmed Instruction</u>						
Busnell	1963	E	23	31	Journeyman Electrician	+
Carson	1971	D	25	63	ABE Reformatory Inmates	0
Coleman	1964	C	52	52	Aircraft Mechanics	+
Cogle*	1972	D	19	19	Managers	+
Delfin &	1979	J	16	17	Crisis Workers	+
Goldberg&	1964	J	33	14		0
Hafn & Holder	1962	J	14	19		+
Hampton	1967	J	328	164		+
Harris	1964	C	302	283	Air Force Personnel	+
Hatraway &	1964	C	?	?	Air Force Personnel	+
Hedberg &	1965	J	67	112		-
Hosmer & Nolan	1962	B	269	151		0
LaGaipa	1968	J	155	155		+
Hughes &	1961	J	70	42	Industry	0

Legend: Study — See references.

* = Studies primarily involving graduate students
 Type (of document) D=Dissertation; B=Book; J=Journal article;
 C=Conference paper; E=ERIC document.

Findings: + = Technology group significantly outperformed control
 - = Control significantly outperformed technology.
 0 = No significant difference.

Based on information and tables supplied by Barbara Shwalb.

Table III. Page 2

ull &	1965	E	30	14	Farm adults	0
arue &	1964	C	55	15		0
ongo & Mayo	1965	E	200	200	Naval Aviation Personnel	0
etcalf	1972	D	65	65	Functional Illit. Inmates	0
eyer	1966	E	26	24	Air Force Personnel	+
eeale &	1968	J	269	185		+
eidt &	1967	J	43	66	Industrial Employees	+
livas	1978	D	25	25	Bank Tellers	0
rr	1968	J	89	89		+
wen & *	1965	J	36	41	Medical Students	0
ills & *	1965	J	34	17	Legal Students	+

usually
Based

asko	1972	D	83	30	Orthoped. Appliance Makers	+
haney &	1967	J	7	6	Inspectors	+
line & *	1973	J	20	20	Psychiatrists	0
yestone *	1966	D	100	100	Researchers	0
olden *	1976	D	20	20	Medical Students	+
atch	1968	D	8	9		0
ones	1965	J	28	14	Industrial Executives	0
onroe	1976	D	33	33	Parents	+
andels & *	1976	J	80	82	Psychiatry Students	0
ryan & *	1970	J	10	10	Psychiatry Students	0
wright *	1979	D	18	15	Elementary Teachers	0

Table III. Page 3

Computer
Assisted

Deignan & *	1978	J	93	154	Medical Students	+
Diem &	1978	J	15	15	ABE Jail Inmates	0
Hirata	1973	D	70	214		0
Motley *	1972	D	16	16	Librarians	0

The attention to programmed instruction can probably also be accounted for by the fact that the procedure lends itself to evaluation. The use of measurable objectives is a key component of the method and it was initially fostered by researchers and psychologists who would have a special interest in promoting research on it.

James Kulik and the Shwalbs are now doing a study of research on CAI with adults and are omitting studies involving graduate students. It will be interesting to see what this investigation finds for the period since 1980. In an interview, Kulik reported that they had found ten good studies and that they seem on first analysis to show that CAI with adults does make a significant difference in outcomes.

A second factor to note about the studies is the limited duration of the courses studied. Twenty-three involved less than 10 hours of instruction and several of these would appear to have been only an hour or two. Only nine involved more than 20 hours of instruction. Thus these studies can hardly tell what would be the effects of regular instruction using technology for extended periods of time. However, as the Shwalbs note, "the longer the instructional period, the smaller the achievement effects for both traditional and technology-instructed adults." (p. 11) If this finding were borne out by more extended studies, it would reenforce the point made earlier, that media are not the significant factors in learning achievement.

The third factor to consider in evaluating these studies is the numbers of subjects. There were only about 2800 (2400 if graduate students are excluded) in the experimental groups in the 40 studies and somewhat fewer in the control groups. The largest group was the 328 experimental subjects in the Hampton study; the smallest was Claney and Teel with seven subjects. Only seven had more than 100 experimental subjects and more than half the studies, 22 in all, had under 50. Generally 50 subjects is considered minimum for a valid comparative study. These are, therefore, hardly numbers on which to base results in which much confidence can be placed.

With all these caveats regarding the data, we quote the conclusion reached by the Shwalbs:

Technology was found to have a positive influence on achievement. The average adult in a technology-instructed class scored at the 67th percentile while the average adult in a traditionally-taught comparison class achieved at the 50th percentile. Specific factors related to effectiveness of technology for adults were: use of different instructors in the traditional and technology classes (i.e., when the same teacher taught both groups, differences in achievement

were markedly reduced;) non-math classes; and instructional duration of less than 10 hours. The average effect size for achievement suggests that instructional technology may be more useful for adults than youth.(5)

While the Shwalbs base their conclusions on the results of the studies, those studies by themselves are insufficient to establish that any of the technologies make major differences in the learning achievement of adults. More confidence can be placed in the conclusions of users of technologies in business and the military because, as stated above, training technologies are seen as "bottom line contributors."

There is, of course, hope that the studies of CAI will produce more significant and positive results. However, the findings of James Kulik, the professor at the University of Michigan under whom the Shwalb's did their work, are not encouraging. In a similar meta-analysis of computer-based college teaching, Kulik and his colleagues identified 500 titles that met their criteria but ended up doing an analysis of only 59 reports that contained sufficient data.(6)

This study concluded that:

Computer-based instruction made small but significant contributions to the course achievement of college students and also produced positive, but again small, effects on the attitudes of students toward instruction and toward the subject matter they were studying. Computer-assisted instruction also reduced substantially the amount of time needed for instruction.

The study made special note of the evaluations done on the two largest CAI programs, PLATO and TICCIT (Time-shared, Interactive, Computer-Controlled, Information Television, developed by the Mitre Corporation of Bedford, MA.) The evaluations were done with NSF funding by the Educational Testing Service. The results were summarized as follows:

The evaluators of PLATO reported that both students and teachers reacted favorably to this computer-teaching system, but that PLATO had no significant impact on student achievement. The evaluators of TICCIT reported that this system resulted in an improvement in student achievement, but students in TICCIT classes were more likely to drop out than those in conventionally taught classes. The evaluators concluded that neither PLATO nor TICCIT had reached the potential so long claimed for computer-based instruction.(7)

An observation that the Kuliks and Cohen make about the two studies is revealing about the problems in doing studies of

instructional approaches that have any generalizability. They note that, although the study was large-scale and costly, "the conditions of the ETS evaluation limited the settings to which its findings could be generalized." (p. 527) They might have added that they were also limited as to types of learners and should not be generalized to adults, particularly adult workers studying in differing settings and with differing motivations than college students.

So far as we can determine, there are no current applications of TICCIT.

In an interview, Kulik indicated that he knows of no good studies of PLATO in industrial settings. Charles Marino, a vice president at Control Data Corporation which markets PLATO, agreed that industry is not interested in controlled studies. "The question asked is: Does PLATO deliver instruction equivalent to more conventional means at less cost? When managers look at the 'bottom line' the answer," he said, "is intuitively obvious." This confirms the point made earlier about the perspective of business on studies.

We now turn to an examination of the other major analysis of studies of the use of technology with adult learners, those done on military training programs by Jesse Orlansky and Joseph String of the Institute for Defense Analyses. (8)

They reviewed studies of PLATO and TICCIT done in a number of community colleges and reached the same conclusions as those summarized above. They did note that in both civilian and military applications the use of computers seems to reduce the amount of time required to achieve learning objectives, even when achievement results are the same. They make several pertinent observations about this result that are worth noting since it is sometimes argued that savings in time are indications of effectiveness.

"To the extent that student time is relevant to the analysis of cost-effectiveness, it is a measure of the cost and not of the effectiveness of training." One of the major reasons for this conclusion is the way in which CAL courses are designed for experimental purposes. The objective is usually to have the students attain the same levels of performance as students in the comparable conventional classes. Therefore, improvements in achievement are not likely to be detected. (9)

Also time has a very different value in military and business setting from that which it has in educational institutions. Because military personnel and workers are usually paid while in training, anything that reduces the time required to achieve a training objective results in a cost saving,

regardless of whether there are any other gains. The situation for schools is different. They seldom have any direct incentives to complete instruction faster. Some students may benefit from time savings if they are able to enter the labor force more quickly or complete training while still receiving income support. "A major consequence of these distinctions," Orlansky and String argue, "is that methods of instruction that are cost-effective for military (and business) training may not be cost-effective in other areas." (10)

It is very apparent from a review of studies of technology in training that the most exhaustive studies on training effectiveness have been done on military programs than anywhere in the civilian sector. The reasons are not hard to find: The military has a huge stake in improving effectiveness since it has a large training budget (\$12.8 billion in 1983). Its maintenance budget is about \$18-20 billion a year or 25% of its total budget. Improvements in training effectiveness in that one area can mean very large cost savings. The result is that the military has been willing to spend large sums both on ways to improve training and on trying to find out whether or not improvements really occur.

Given this situation it would be reasonable to expect that very definitive studies would have been done on training effectiveness, particularly in areas where the costs of training are high and the consequences of failure in effectiveness could mean loss of lives as well as dollars. Unfortunately, Orlansky did not find this to be the case. There are some important and useful studies, as we shall see, but Orlansky identified a major gap in all of the studies:

The effectiveness of training should really be measured in terms of performance on the job, e.g., ability to diagnose malfunctions and to replace faulty parts, ... ability to operate tanks and radar, ... overall effectiveness in combat. However, this type of objective performance data is almost never collected. (11)

Only in the case of flight simulators is there evidence on the transfer of training to actual flight situations, i.e., pilots trained on simulators can actually fly planes.

A second problem with many of the studies is in the area of costs. Cost analyses are either not done, or cost data is too inadequate for valid comparisons. Orlansky says:

It is easy to overlook the fact that resources are required to achieve any level of effectiveness, and that the amount of resources provided for training can readily influence the level of effectiveness that may be achieved.

Thus, it is quite meaningless to consider the effectiveness of training without also considering, at the same time, the cost associated with that level of performance.(12)

Orlansky did assessments of three types of training devices: flight simulators, computers, and maintenance simulators. The overall finding was that:

these methods of training are as effective as the more conventional methods to which they were compared (with the caveat that) effectiveness has been measured only at schools and not subsequently on the job. These methods of training cost less to acquire and use, but only limited cost data are available.(13)

In this section we will examine what Orlansky has to say about the effectiveness of various technology training devices and leave to a later section the more detailed examination of his cost-effectiveness findings. To anticipate the major conclusion, which justifies the separation of cost and effectiveness discussions, in 1979 Orlansky and String said:

Direct comparisons of the cost and effectiveness of different methods of instruction are not now possible because only incomplete cost data were found.(14)

That statement was based on an analysis of 30 studies; when the following statement was made in 1933 they had found 48 studies and were able to qualify the above conclusion somewhat:

Reduction in the time needed by students to complete their courses (about 30% on average), when translated into reduced costs for student pay and allowances, fewer instructors and support, can represent real cost savings due to the use of CAI or CMI. However, life-cycle costs (i.e., costs for the design, development and delivery of the training program throughout its useful life) for computer-based and conventional instruction must be considered before we know whether computer-based instruction actually produces overall savings in costs.(15)

The conclusion reached in 1979 on computer based instruction for the military was:

Much of the data come from experiments of limited duration with relatively few students (note the similarity to the studies examined by the Swalbs); by contrast, some CMI systems have been used four years. All findings are confounded by effects that may be due either to CAI or CMI, in comparison to conventional instruction, or to the revisions in course materials needed to modify a course from conventional to CAI or CMI instruction.

CAI and CMI save about 30 percent (median) of the time required by students to complete the same courses given by conventional instruction...Student attrition appears to increase with CAI and CMI...but changes in student quality may also account for this increase.(16)

Two points should be noted: First, courses are almost always structured more systematically when they are adapted to CAI or CMI; were conventional courses similarly restructured, they too might produce improved results. This means that it is almost impossible to hold the course content constant while only changing the mode of delivery.

Second, in any large scale study it is almost impossible to hold student quality sufficiently constant to rule out changes in students as a factor in any differences of results. Even when students are matched statistically, changes not detected by the data may influence the outcome.

In 1983, after closer analysis of a larger number of studies, Urlansky found only eight (six CAI and two CMI) systems where achievement of students was compared with achievement in the same courses taught by conventional instruction. (See Table IV. Commenting on the data, he wrote:

The table shows clearly that student achievement at school with CAI or CMI is about the same as, or in some cases superior to, that with conventional instruction. The amount of superior achievement is small.(17)

The results found for maintenance simulators were similar:

Student achievement in 12 courses that used maintenance simulators was the same as or better than that in comparable courses that used actual equipment trainers; in one case, student achievement with a simulator was less.(18)

While the cost data tend to favor use of simulators, the overall conclusion reached is not encouraging for those who would like good studies on which to make decisions:

The data on the cost and effectiveness of maintenance simulators have not been collected systematically. Therefore, there is no basis at present for making trade-offs between the effectiveness and cost of different types of maintenance simulator....There have been insufficient studies on the amount of student time saved with the use of maintenance simulators. There have been no studies on whether the use of maintenance simulators influences the amount of student attrition at school. There have been no

Table IV.

FIGURE 10. Student Achievement at School: CAI and CMI Compared to Conventional Instruction

METHOD OF INSTRUCTION	SYSTEM	SERVICE	LOCATION	STUDENT ACHIEVEMENT AT SCHOOL (compared to conventional instruction)			TYPE OF TRAINING
				BETTER	SAME	WORSE	
CAI	BM 1500	A	SEAL CAS		• • • •	• •	ELECTRONICS ELECTRICITY
		N	SAN DIEGO			• • • • •	
	PLATO IV	A	ABERDEEN		• • •		MACHINIST ELECTRONICS RECPE CONVERSION A/C PANEL OPERATION MEDICAL ASSISTANT VEHICLE REPAIR
		N	SAN DIEGO		• •	• • • •	
		N	SAN DIEGO		• •		
		N	NORTH ISLAND		• •	•	
		AF	SHEPPARD		• • • •		
		AF	CHARUTE				
	LTS-3	AF	KEESLER		• •	•	ELECTRONICS WEATHER
		AF	KEESLER		•		
	VECT	N	NORTH ISLAND		•		TACTICAL CO DRG (S 3A)
	SHIM	N	DAN RECK	•	•		FIRE CONTROL TECHNICIAN
	PLATO IV	N	DAN RECK		• •		FIRE CONTROL TECHNICIAN
TOTAL				1	24	19	
CMI	NAVY CDS	N	MEMPHIS		• •		AVIATION FAMILIARIZATION AV TECH FUNDAMENTALS
		N	MEMPHIS		• •		
	AS	AF	LOWRY		•		INVENTORY MGMT WATERMEL FACILITIES PREC MEASURING EQPT WEAPONS MECHANIC
		AF	LOWRY		•		
		AF	LOWRY		•		
		AF	LOWRY		•		
	TOTAL			0	4	0	

9 34 01 00

FIGURE 11. Amount of Student Time Saved by CAI and CMI, Compared to Conventional Instruction

METHOD OF INSTRUCTION	SYSTEM	SERVICE	LOCATION	STUDENT TIME SAVINGS (compared to conventional instruction)										TYPE OF TRAINING
				-100	-50	0	50	100	150	200	250	300	350	
CAI	BM 1500	A	SEAL CAS				•	• •						ELECTRONICS ELECTRICITY
		N	SAN DIEGO					• • • •						
	PLATO IV	A	ABERDEEN			• •	• •							MACHINIST ELECTRONICS RECPE CONVERSION A/C PANEL OPERATION MEDICAL ASSISTANT VEHICLE REPAIR
		N	SAN DIEGO		• •	• •	• •							
		N	SAN DIEGO											
		N	NORTH ISLAND											
		AF	SHEPPARD			25								
		AF	CHARUTE					• •	•					
	LTS-3	AF	KEESLER				•							ELECTRONICS WEATHER
		AF	KEESLER											
	VECT	N	NORTH ISLAND							•				TACTICAL CO DRG (S 3A)
	SHIM	N	DAN RECK				•							FIRE CONTROL TECHNICIAN
	PLATO IV	N	DAN RECK	•			•							FIRE CONTROL TECHNICIAN
CMI	NAVY CDS	N	MEMPHIS							• •		• •		AVIATION FAMILIARIZATION AV TECH FUNDAMENTALS
		N	MEMPHIS											
	AS	AF	LOWRY											INVENTORY MGMT WATERMEL FACILITIES PREC MEASURING EQPT WEAPONS MECHANIC
		AF	LOWRY											
		AF	LOWRY											
		AF	LOWRY											
	TOTAL													

From J. Drlansky, "Current Knowledge and Projection on Assessing the Effectiveness of Training," Institute for Defense Analyses, 1983, p. 8.

studies to collect objective measures of performance of maintenance technicians on the job after training, either with simulators or actual equipment trainers. (Emphasis added.) (19)

One of the observations that Orlansky makes many times is on the incompleteness of the studies that have been done. For example, with respect to the maintenance simulators he notes that certain key studies were not done:

Some of the presumed advantages of simulators were not examined and therefore cannot be evaluated, e.g., their ability to teach students how to correct a wider variety of malfunctions than can be done with actual equipment, their superior availability compared to actual equipment trainers, and their ability to measure and report student performance both to students and instructors....There are no cases except one where the effect of training upon job performance is examined; it found no differences between simulator and actual equipment; however, it did not report the amount of transfer of training from school to the job. (20)

The omissions mentioned would seem to be rather important matters on which the military would have wanted data. The reasons for the omissions are not because the desirability of obtaining such data were unrecognized but rather because they are just so difficult to obtain. The more variables one begins to try to examine, the more difficult it is to get valid comparative situations and enough information on which to draw conclusion. The military (and the civilian sector) have had to rely on the presumed advantages of simulators and use them when they appear to be cost effective.

Even to relate cost and effectiveness is difficult. As Orlansky notes:

We cannot answer such interesting questions as how effectiveness might vary with cost or how cost might vary with effectiveness, because no such trade-offs have been undertaken. We have only one-point comparisons of the costs of maintenance simulators and of actual equipment trainers that have been shown to have equal effectiveness for training at school. (21)

Another complicating factor in gathering comparative data are the attitudes of the instructors — a factor in the assessment of any instructional technology. The findings of Orlansky and String on this issue have wide applicability:

Instructors, in general, favor the use of actual equipment, rather than simulators... Reasons given for this

preference are that students need to train with actual equipment and that the lack of realism in simulators can interfere with effective training. Such reasons cannot be dismissed, because the views of instructors can influence the way in which simulators are used in a course; an inappropriate use of a simulator may easily make it not effective and therefore not efficient for training.(22)

Another observation about simulators can apply to almost any instructional technology:

It may be that less expensive devices are as effective as more expensive ones for maintenance training. However, we lack both a metric and guideline to identify either the physical or functional characteristics of these devices that influence the effectiveness of training....Different levels of complexity and of fidelity may be required for the manual, hands-on skills needed in maintenance than for those which involve primarily knowledge and procedures associated with the diagnosis of malfunctions and troubleshooting.(23)

If there is this much complexity in analysing the effectiveness of maintenance training, where, one would naively think, the performance measures would be easy to specify, it is no wonder that there are few adequate studies of the use of instructional technologies for teaching more complex subjects. Much of the Orlansky-String paper on computer-based training is devoted to similar critiques of the studies in that area.

We have quoted the studies by Orlansky and String at some length in this report because we have found their analyses to be the most comprehensive and thorough of any that we encountered. We were reinforced in this judgement by findings ourselves frequently referred to their work by others whom we contacted. Their assessments of the state of studies shows that little has changed since Matthew Miles, in his seminal 1964 study of innovations in education wrote:

A near-axiomatic statement is this: Educational innovations are almost never (emphasis his) evaluated on a systematic basis. Perhaps every educational researcher ought to spend part of his apprenticeship painstakingly illuminating this text on parchment:

The creators of experimental programs...have little question about the efficacy of the changes they have introduced. They know that the courses they have developed are the best possible under existing conditions (read "technologies" for "courses" to apply here); and in the light of this assumed fact, systematic evaluation seems superfluous.(24)

It is likely that Orlansky and String would agree, as we do, with Miles' list of reasons for this state of affairs:(25)

* There are few criteria of educational effectiveness. (In training, the criteria are somewhat easier to come by than in education, but, as Orlansky pointed out, the key criterion is performance on the job, and that one is almost never applied.)

* Adequate assessments are expensive in time and money (case in point: a serious evaluation of a new physics curriculum cost three times the cost of the production of the curriculum. What developer of a new technology is going to invest that kind of money in evaluation?)

* Sound assessments require use of controlled situations, measurable procedures, and operation over a significant period of time. (As we have seen, most of the studies we have examined have had few controls, little information about procedures, and certainly were conducted over too short a time to be meaningful.)

* The zeal of the promoters of innovations or new devices appears to have self-justifying strength. (As we shall see in Chapter XI, in each generation there have been enthusiastic advocates of various technological devices who have been convinced and, for awhile, convinced others, that their particular device or program would be the revolutionary breakthrough that the world was awaiting.)

* Organizations are usually more interested in the impact of educational innovations on the structure and power relations of the organization than on the effects on learners. (We have not discussed this facet of the impact of devices on organizations, but it is certainly one that bears examination as one considers the likelihood of any particular device being adopted and successful.)

Another study just being completed throws some additional light on training practices and preferences in companies and service organizations. David Kelley at Northern Essex Community College in northeastern Massachusetts sent a questionnaire to 204 firms and organizations in the region employing 100 or more, of which 108 or 53% replied.(26)

"The only thing that surprised me," reported Kelley in an interview about the findings, "was how traditional the companies are in their training preferences and practices. Even with the numbers of high tech firms in the sample, there was just not much interest in the use of high technology in training. The larger the company, the more sophisticated and extensive their training. About one-third of the sample, mostly smaller firms that did little training on their own, were 'very interested' in possible services from the college."

Among the significant findings that substantiate Kelley's conclusion regarding the traditional orientation toward training were these:

Responses to a question on preferences for various training techniques, on a scale of 1 (always preferred) to 7 (never preferred), the results were as follows:

<u>Technique</u>	<u>% Rating 1-3</u>	<u>% Rating 4-7</u>
Traditional lecture	51	49
Computer Assisted Instr.	30	70
Video	53	47
16mm Films	43	57
Audio Cassettes	42	58
Programmed Instruction	32	68
Games and Simulations	34	66

When asked to rate on a similar scale interest in having various training services provided by the college, services involving any use of technology generally rated rather low with 30% or less rating them in the "interested" range of 1-3.

Nor were very sizable portions of the training budgets devoted to any technology based training. About 75% placed the percentage of their training budgets devoted to this kind of training at less than 25%.

In connection with our later discussion of the costs of training, it is important to note that Kelley's survey did not ask for the amounts of training budgets. "because," he explained, "firms in a competitive situation do not like to share that kind of information."

One indication that overall training budgets may not be large was the finding that 67% had no full-time trainers and 72% had no part-time trainers. "Most training, we found in follow-up calls," Kelley said, "was being done by other employees who spent a part of their time on training. There are not many professional trainers among the firms in our sample."

While Kelley's results cannot be extrapolated to the nation as a whole, his sample includes firms of the kind that are found in many parts of the country. The findings are at least suggestive that, as yet, the possibility of using technology in a significant way to meet training needs has not penetrated a large proportion of firms, particularly those with fewer employees and smaller budgets.

VI. CAI IN ADULT BASIC EDUCATION.

In this section we will examine the effectiveness of CAI for meeting the learning needs of displaced and working adults in need of basic skills or a high school diploma.

The Great Neck (N.Y.) Public Schools have an adult basic education CAI program in their Adult Learning Centers. The program used was developed by the Computer Curriculum Corporation in Palo Alto, CA (CCC). The students, some of whom have been employed, used CAI for basic skills, problem solving and career exploration. In 1982-83 a study was done of the 170 who utilized CAI for a minimum of five hours a week. These students averaged 196 hours of attendance while students who did not use CAI averaged 108 hours. The CAI students averaged 3.71 years of growth in reading and 3.55 years in mathematics. The gains for the non-CAI students were not given but, since the objective was to achieve average gains of 2.5 years, it has to be assumed that these were considered significant gains.(1)

A problem in interpreting these results that was pointed out by Russell Kratz, the State official responsible for monitoring this program, is in determining how much of the differences in outcome results from the 80% more time spent by the CAI students and how much from better instruction provided by the CAI program. It could well be that the chief advantage of CAI is that it motivates students to study more. This interpretation is borne out by the results on an attitudinal questionnaire.

Ninety-eight percent of the students said that they enjoyed studying with the help of the computer and what they liked most was the clear explanations and immediate feedback. Seventy-three percent said that they would like to use the computer more often and only five percent would use it less often.

When given a choice of eight modes of study, 85% rated CAI among their three favorite modes. Unfortunately the report did not give the results for the other modes, particularly classroom instruction, so this comparison is not complete.

While this report seems to give strong support to the value of CAI in an adult basic skills program, it, like so many project reports, is flawed in ways that make it an inadequate basis for any general conclusions about the effectiveness of CAI. The study was not intended to be a scientifically valid comparison of CAI and non-CAI students; it was a funded project evaluation run and interpreted by the project administrators. No information is given about the characteristics of the students or how they were assigned to the different programs, but it can be

assumed that it was not a random assignment. We do not know from the report whether the non-CAI students studied the same content, nor how much contact the CAI students had with teachers and whether these were the same teachers for both groups. And, as noted, we are not given the results for the non-CAI students, nor told whether or not they were given the same attitudinal questionnaire, although the presumption is that they were not.

There is also no discussion of the costs of the program, although the local district officials have been conducting the program since 1977 and, according to Kratz, believe that it is cost-effective. However, the program continues to be supported with grants from the Adult Basic Education Program but this is not to be interpreted as a judgment on its cost-effectiveness.

We have discussed this program and the problems with its evaluation in some detail because it is cited as one of the exemplary programs in the country in the use of technology for adult basic education. Michael Miles, the Marketing Manager for Instructional Systems, Inc., the vendor for the program, referred us primarily to this program as the best one using the CCC program with adults. It was similarly cited by New York State Education Department officials. It has been featured at many state and national conferences and the project director, Elizabeth Buckley, is widely recognized as one of the leading authorities on the use of technology for adult basic education. The fact that this program has this visibility is an indication of how few good programs using technology for adult basic education there are. For all its problems, it is in the lead in trying to find ways to meet the pressing need for better ways to deal with the critical problem of adult skills.

Our commentary on the evaluation is not intended to denigrate CAI generally or the CCC program as an effective tool for meeting the basic education needs of some adults. The program may work as well -- or even better if a valid study were done -- than its advocates believe. The point to be made is the Great Neck experience and study do not by themselves provide a basis for making a judgment about effectiveness. At this point all we have are claims and studies even more flawed than the one from Great Neck.

This point was reinforced in our interview with James Nutter, the director of one other CCC project to which we were referred by Miles. This project is in western New York in an area heavily affected by the closing of steel mills. The Niagara-Orleans EOCES, an intermediate public school district, installed a CCC computer with eight terminals at a cost of \$35,000. The program was primarily designed to serve steel workers who were in danger of losing their jobs. The new steel employer in the region, Allegheny-Ludlum, will only interview persons with high school diplomas, which many of the older workers do not have. There is therefore, a strong incentive to enter the program.

However, scheduling problems have so far limited use of the program. The terminals are being used only 50% during the regular eight-hour day, although they are theoretically available 24 hours a day, with one terminal even being in a union hall. "At that rate the system is not cost-effective," according to Nutter.

The program has not been in place long enough for there to be learning results. The students are very positive about the program and, indeed, report that they prefer it to the PLATO system which is available to them in the plant. However, Nutter makes sure that every student has contact with a teacher at some time during each day. He is convinced that contact with a "warm body" is a key factor in the students' for CCC and for their success with it.

Nutter points out, as have others whom we interviewed, that one of the key problems in getting workers into basic skills programs is one of attitudes. When the workers are employed, they see no reason to seek to upgrade their skills or get the high school diploma that they lack. When they are laid off, it takes quite a while for them to be convinced that they are not going to get their old jobs back and by then they have so many problems that it is difficult to get them to focus on study. Moreover, the rewards for getting the diploma are not very alluring. Nutter: "We have to tell them that after attending anywhere from 100 to over 800 hours they may then qualify for a \$5.00 a hour job--this to people who had been earning \$15-20, and who on welfare come out just about as well as if they took the \$5.00 job."

As a further indication of the complexity of the problem, Nutter has opened access to the computers to anyone in the community who wants to use them since the time was available. There are 52,000 adults lacking high school diplomas in the area served by the BOCES but only ten people responded to a general announcement of availability. Nutter then sent personalized letters of invitation to 150 who had taken a test of basic skills and scored below ninth grade level. He heard from less than 20, five actually began the program and, at the time of the interview, only one was still with it.

Another setting that is using CAI, in this case PLATO, to teach basic skills to adults is Central Piedmont Community College in Charlotte, NC (CPCC). The Adult Basic Literacy Education (ABLE) centers are located in a shopping center, a community center and a neighborhood church. (2)

PLATO was selected after a search of available alternatives because the CPCC staff was impressed by the data that showed that children using PLATO could raise their reading

levels on average one grade level in 20 hours in contrast to the usual 180 days of elementary school instruction to achieve one grade level improvement. (The report supplied by CPCC did not give the instructional hour equivalent for the classroom instruction.) CPCC decided to see if PLATO could help improve on the time required by adults to gain one grade level. At CPCC 50 hours of tutoring were required to raise adults one grade level, while in North Carolina community colleges generally, students take 150 hours to move up one grade level.

Students whose skills are at the fourth grade level or below receive considerable individual tutoring from volunteer tutors, one of whom is assigned to each student. In addition to PLATO, they use other software packages from some twelve different publishers, such as one by Apple that uses a crossword puzzle format to teach word meanings. For students in the fourth through eighth grade level, various other technological systems are added including tapes of popular television shows. The students follow the program in the written script and thus learn to associate print and sound. These students work more independently but an instructor is always available. Students who have achieved mastery at the eighth grade level then move into one of several high school completion programs including the PLATO GED preparation courses.

In assessing the first year's results, Hagemeyer said, "The system is time-effective — the average time required to gain one grade level in reading and math has been just over 20 hours. We are not sure yet whether or not it will be cost-effective." (3)

Part of the reason for the uncertainty on cost-effectiveness is the same as in Western New York — the difficulty of getting high enough utilization of costly equipment and software to bring the per hour costs down to a level competitive with the alternatives, particularly volunteer tutors. Wilson believes that more recent utilization data will show that the program compares favorably with traditional ABE instruction.

Of course, the value of the learning time gained also must be taken into account. However, for persons who are unemployed or studying in non-work time, the value of the time saved in purely economic terms may not be great — unless, of course, earlier completion allows the person to go to work, thus ending costs to society for unemployment or welfare. What needs to be determined is whether students who move more quickly through the basic skills program tend ultimately to complete high school or attain higher levels of skills than students who go more slowly through traditional programs.

Whatever the eventual determination on the cost-effectiveness of systems like PLATO, several project directors

did cite PLATO costs as a limitation, particularly when the system was used to serve low-income adults. This was because such programs, often ABE and basic skills programs, are traditionally third-party funded -- by the federal government, by local communities or by nonprofit organizations. Such programs are notoriously under-funded to begin with, making a sophisticated CAI system like PLATO difficult to acquire in the first place.

For example, the appropriation for the federal Adult Basic Education Act is only \$100 million for the entire country (in contrast to over \$12.5 billion dollars in financial aid awarded to post-secondary students.) State expenditures also are not large. In 1980 the states spent an average of six dollars for adult basic and high school equivalency education for each person age 16 and over, out-of-school, and lacking a high school diploma or equivalent; but only thirteen states (among which Washington, DC, and Puerto Rico were counted) exceeded the national average.(4)

But more importantly, when the third party funding runs out (being generally short-term) it is difficult to sustain the expenses of such a CAI system. The individuals served are not able to pay themselves for the learning, and there is too often no company or other source willing to foot the bill.

VII. TECHNOLOGIES COMPARED.

During our interviews and in our review of the literature there were many comparisons made among alternative approaches to training, particularly between traditional classroom instruction and various technologies. These comparisons are summarized in Table V.

As would be expected from our earlier commentary on systematic studies, these comparisons represent more subjective judgements of the individuals or organizations involved than any rigorous study. Moreover, the comparisons are almost always between conventional instruction and some one technology, rather than among technologies.

For example, Urlansky and String found only a few comparisons between computer- and non-computer-based approaches to individualized instruction. In comparisons in 12 courses, savings in student time with individualized instruction ranged from 51-64%. The addition of CAI to five of these courses produced additional time saving of five percent; the addition of CMI produced no additional gains. (1)

Such comparisons are important because of the considerable additional cost in using computers. If the time-savings are comparable, the burden of justifying the additional cost would appear to be placed on those who wish to use computers.

As Urlansky and String observe:

These data do not necessarily imply that the addition of computer support to individualized instruction is not cost-effective. That would depend, in each case, on whether the incremental costs of computer support are offset by cost reductions in other areas, such as for the number of instructors and support personnel, administrative services, and other factors. (2)

Another way to look at the findings from our material is in terms of the advantages and disadvantages attributed to the various technologies. These are presented in Table VI. In general, the advantage common to all media is that they can deliver instruction to students without the physical presence of an instructor and usually in ways that are more tailored to the needs of the individual student than traditional instruction. The common disadvantage is that they require more effort and money to produce than traditional instruction without necessarily producing compensating benefits.

Table V

Comparisons among Alternative Training Technologies

Alternatives Compared (Site/Source)	Purpose of Training	Learners Served	Findings/Observations
CLASSROOM vs.			
Television (Wayne State U./ Straebel)	Degree- Credit	Employed Workers	No significant difference in learning achievement. Workers enrolled who other wise would not have earned college degrees. No cost-effectiveness data
Videotape Tutorial (ITT-Telecom/ Harmon)	Introduction to new Equipment	Engineers Technicians	Videotape captures exper- of specialists. Flexible time and place. Reduced time to completion by three-fourths. No cost or cost-effective- ness data.
Self-Instruction/ PLATO (U.S. Army, Fort Monroe, VA/ Gustafson)	Basic Skills	Military Recruits	PLATO improves "time on task." Access to "live" instruction important. PLATO improves motivation (over traditional self- instruction and classroom Classroom ineffective. No cost-effectiveness data

Table V, continued

Comparisons among Alternative Training Technologies

Alternatives Compared (Site/Source)	Purpose of Training	Learners Served	Findings/Observations
CLASSROOM vs. -----			
CCC (Western New York Regional Center/ Nutter)	Basic Skills	Displaced Workers	Students prefer CCC. Instructor availability is critical. Difficulties encountered in scheduling students into program. No cost-effectiveness data.

Videotape and Computer-Based (Digital Equipment/ Leppert)	Upgrade Skills	Company Personnel	CAI reduces time to finish by two-fifths. Videotape not effective. Classroom too prescriptive. Costs \$15,000-\$16,000 per hour of finished course. Cost-effective if 300 students require same course within three years.

Videoconference and Computer-Assisted (IBM/Munns) Munns)	Upgrade Skills	Service Personnel; Assemblyline workers; Engineers	No significant difference six months after instruction (CAI). Videoconferencing least effective. Students prefer classroom with skilled instructors. CAI less costly for 100 or more students.

Table V, continued

Comparisons among Alternative Training Technologies

Alternatives Compared (Site/Source)	Purpose of Training	Learners Served	Findings/Observations
CLASSROOM vs.			
"Hands-On" with Equipment (Business offices/ Beasley)	Use of High-Tech Equipment	New Office Workers	"Hands-On" overcomes fear of equipment. Effective if done "on-site" with co-worker "coaches." No cost or cost-effectiveness data.
On-the-Job with Equipment (Western Union International/ Ingraham)	Use of New Equipment	Field Service Staff	Training embedded in equipment. "Hands-On" essential to effective learning. Changes in equipment too frequent to justify time away from job for training. No cost or cost-effectiveness data.
Simulators and Embedded (Manpower Services/ Fromstein)	New Word Processors	Temporary Secretarial Workers	Training on device to be used on job more efficient. Traditional classes too slow. Simulators require extra transition to actual devices. Training on device least costly. No detailed cost-effectiveness data.

Table V, continued

Comparisons among Alternative Training Technologies

Alternatives Compared (Site/Source)	Purpose of Training	Learners Served	Findings/Observations
CLASSROOM vs.			
Mediated System (text, audio, video, CAI, and embedded) (Dupont/Jenkins)	Use of Blood Analysis Equipment	Medical Technicians	Learners more confident of own abilities. Reduces time to finish by two-fifths. Reduces staff by one-half. Reduces cost by one-half.
VIDEOTAPE vs.			
Telecourses (Oklahoma State U/Jobe)	Math Skills	Remedial Math Students	Videotape tutorials provide instruction when needed. Students don't respect TV. Telecourse not interactive. Very cost-effective. No detailed cost-effectiveness data.
Audio (U. of Nevada/McMeen)	Inservice Training	Off-Campus Professionals	No significant difference in outcome. Audio much simpler and cheaper to produce and use. No detailed cost-effectiveness data.

Table V, continued

Comparisons among Alternative Training Technologies

Alternatives Compared (Site/Source)	Purpose of Training	Learners Served	Findings/Observations
CAI vs.			
Emulator and CAD/CAM Equipment (Milwaukee Area Technical College/ Langer)	CAD/CAM Operators	New and Current Employees	Emulator gives training in realistic problem-solving without tying up machines CAI restrictive as tutor. CAD/CAM equipment costly a training device. No detailed cost-effective ness data.

Table VI.

ADVANTAGES AND DISADVANTAGES OF MEDIA.

A. BROADCAST TELEVISION

ADVANTAGES	DISADVANTAGES
TV sets in almost every home.	Requires large audience to be cost-effective.
Reach large numbers at low per student cost.	Students miss contact with faculty and other students.
Reach students who cannot come to campus.	No interaction with instructor or program.
Magnify images, slow motion, repeated action, and combine things and events that do not occur together in nature.	Access limited to broadcast schedule.
Can extend the impact of outstanding teachers and experts with specialized knowledge.	Development costs and time high.
Effective for awareness and motivation.	Perceived as entertainment medium and often not taken seriously as education medium.
Technical production capabilities well-developed and widely available.	
Basic equipment available at low cost.	

Table VI.

C. VIDEO DISK

ADVANTAGES

Can deliver same images as broadcast television but without transmission cost and scheduling problem.

Can deliver same images as videotape, but provides better access to individual segments and in quantity disk is cheaper than tape.

Very large storage capacity — 54,000 frames per side.

Any frame or segment can be accessed almost instantly.

When produced in quantity, individual disks are very low cost.

Disk virtually indestructible and laser disk never wears out.

Can present individual pictures, pages of text, slow motion and full motion with two sound-tracks.

Can be used at student's convenience; student can control pace and replay any segment.

Can be controlled by computer to provide multi-media, interactive programs.

Courses can be replicated without variation in content and quality.

Has "freeze frame" capability.

Can provide models of skilled performance.

DISADVANTAGES

At present copies have to be made from master disk at special duplicating facilities. (Writable disks expected in near future.)

Masters costly to produce.

Small numbers of playback devices in place now.

Disk players more costly than tape.

Master disk and copies cannot be edited or updated.

No standards for disks or players; disks not interchangeable among machines of different makes.

Effective interactive programming difficult to produce.

Table VI.

D. COMPUTERS.

ADVANTAGES

Cost of computers going down and capacity going up at rapid rate.

Very reliable and relatively easy to use.

Becoming widely available in businesses, educational institutions and homes.

Can store and give rapid access to vast quantities of information.

Essential for dealing with large quantities of data and complex symbol systems such as mathematics.

Can be connected with each other and with many other devices, especially video disk players, science equipment, printers and telephones, permitting very sophisticated and rich learning environments.

Highly interactive permits very individualized instruction.

Patient, non-judgemental, impersonal, private.

Student can control many aspects of course delivery: pace, timing, sequence, level, content.

Huge storage capacity permits collection and analysis of detailed records of student performance for management and research.

DISADVANTAGES

Rapidity of change in machines tends to speed obsolescence of machines, software and user skills.

Costly to produce effective courseware.

Limited good software.

Inadequate numbers of persons skilled in producing good courseware.

Lack of standards so that courseware not interchangeable among machines.

May be impersonal and dehumanizing.

Many adults fear computers.

Keyboard skills required for many applications and not possessed by most adults.

Access highly dependent on socio-economic status.

Table VI.

D-2. COMPUTERS.

Presents materials at a wide variety of educational and learning ability levels — from simple to complex.

Adapts to a wide variety of settings, on the job, in schools, and elsewhere.

Courses can be replicated without variation in quality and content.

Software easy to edit and update.

Computer can be learning tool as well as tutor; can be used to teach its own use.

No ceiling on learning -- there is always more to learn about and with computers.

Tends to increase "time on task" — a key factor in successful learning.

Usually reduces time required for achieving educational and training objectives.

As wordprocessor, powerful tool for increasing amount and quality(?) of student writing.

When connected to communication network, can give access to courses, data banks and other people.

Can simulate almost any complex system; as simulator, reduces costs, risks, time.

Effective in teaching fixed sequences of operations.

Can be used by most disabled individuals; in some cases provides only effective form of communication.

Table VI.

E. EMBEDDED TRAINING.

ADVANTAGES

Makes effective use of power of microchips.

Reduces worker memory burden.

Provides training when needed.

Eliminates need to learn things that may not be needed.

Forces designers of devices and systems to consider user's learning requirements.

Reduces cost of training and maintenance.

Assures currency of information at time of application.

DISADVANTAGES

High cost of initial design: must try to anticipate all contingencies.

Workers may not have time to learn when needed.

Reduces importance of human skills.

Makes jobs routine and boring.

Insufficiently flexible to deal with emergencies or unanticipated situations.